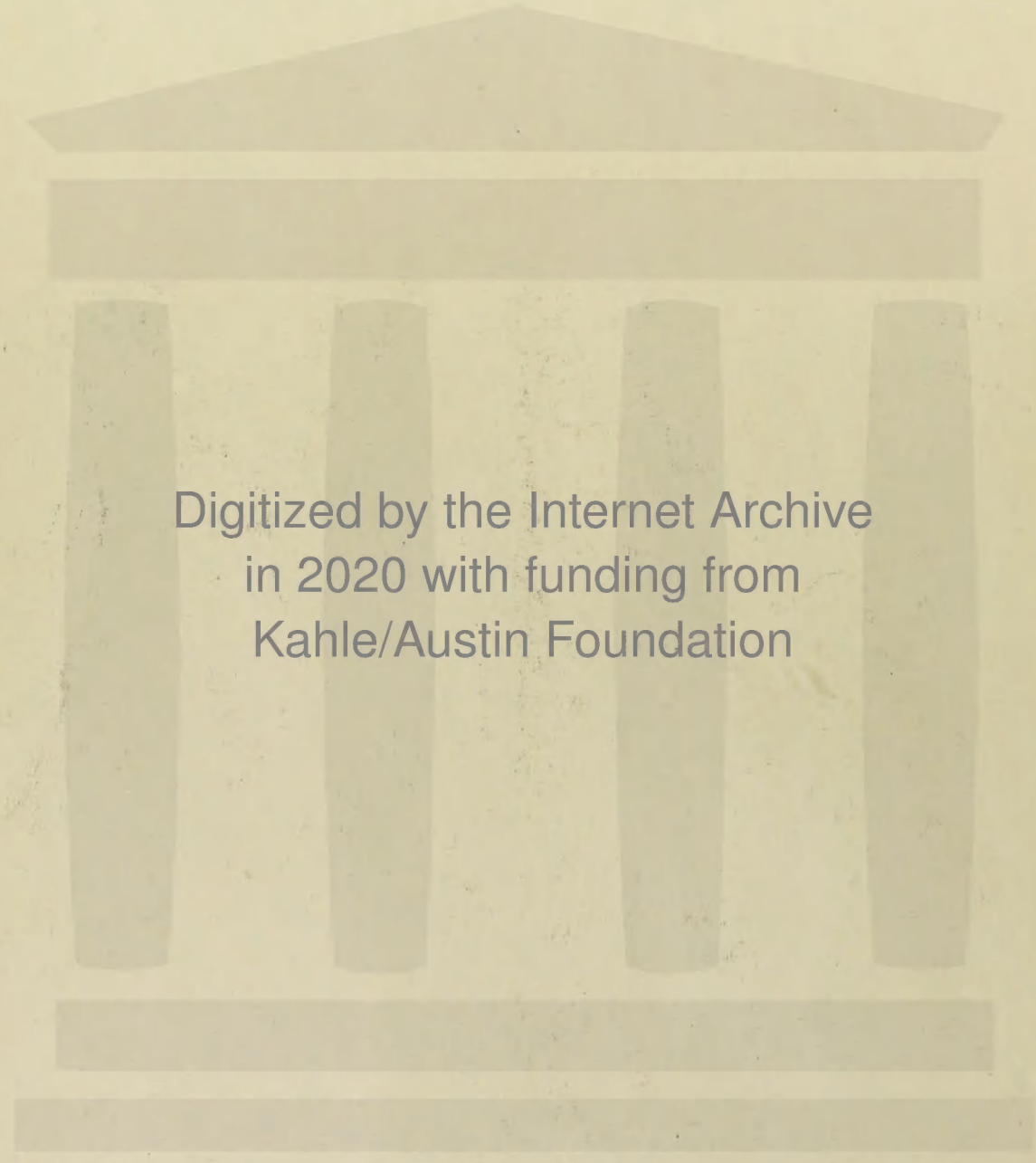
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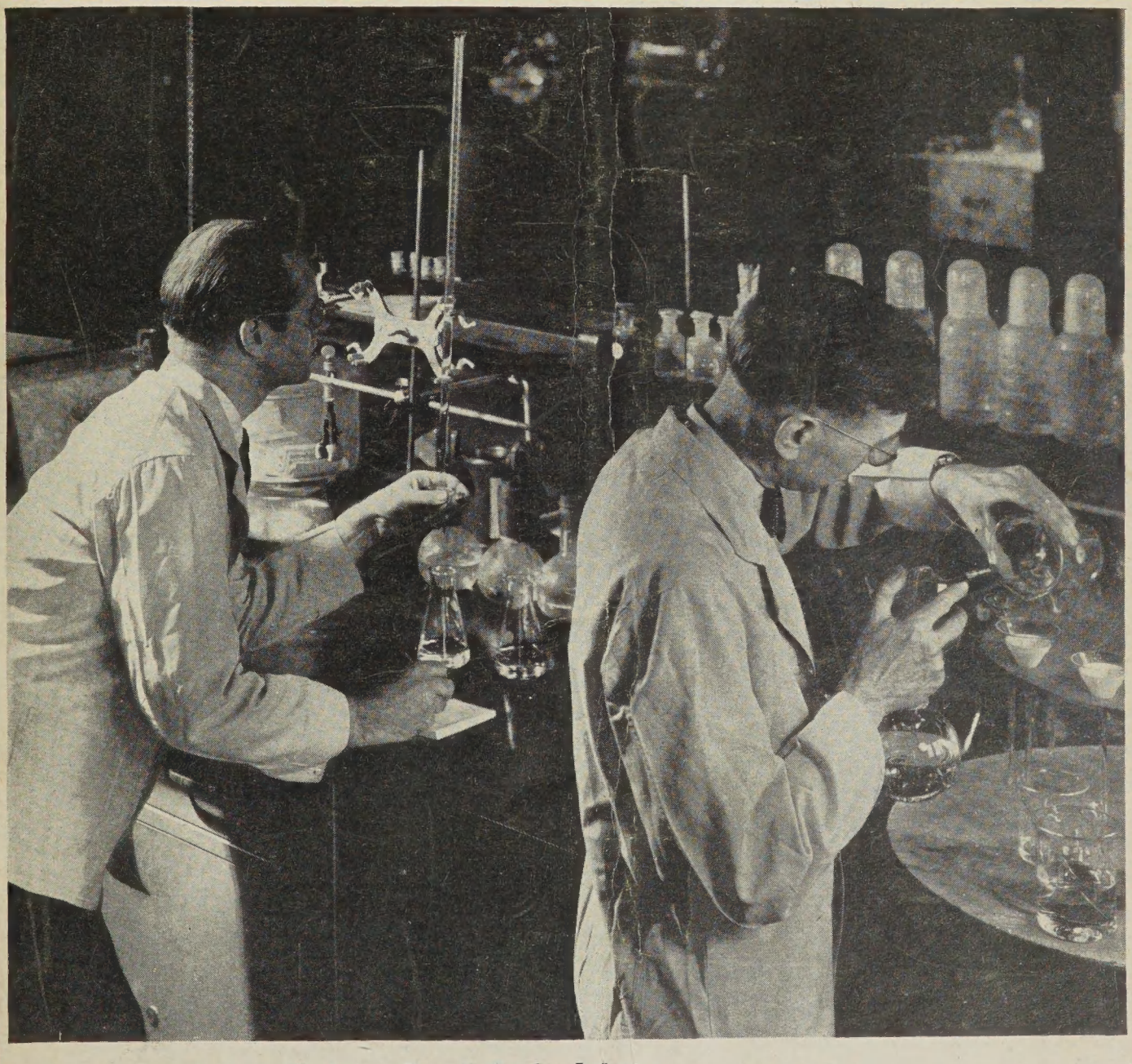
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REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Exploring New Paths for Industry . . . See page 1

The Story of INDUSTRIAL RESEARCH

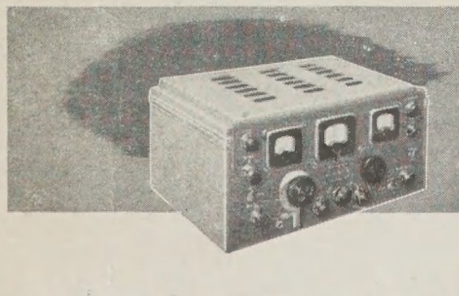
Anniversary Issue No. 1



MESSAGES GOT THROUGH ON THE "BANANA NET"

THERE is many an exciting story about how amateur radio operators now in the services have helped extend the lines of victory around the world. There's the one about the "Banana Net"—the name the boys gave to the radio network down in the Panama jungle. As the G. I's have it, "it rains continually during the rainy season but only once a day in the dry season". The "Banana Net" is just one link in the vast network set up by the AACS—Army Airways Communications System. The AACS safeguards tens of thousands of lives by relaying weather reports, coordinating information on enemy movements and by bringing home or locating flying ships that are down or in trouble.

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Our Cover: Taken in one of the research laboratories of the Aluminum Company of America, this photograph graphically illustrates the dependence of many industries on chemical research. It points up in particular the article on page 35.

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Previews of the Industrial Horizon

By A. P. Peck

SINCE THIS number of Scientific American, the first of 12 100th Anniversary Issues, is devoted to reviews and previews of the past, present, and future of industrial research, it is fitting that this month's Industrial Horizons be scanned through the eyes of outstanding men of science and industry. The following quotes fit neatly into the integrated pattern of things to come out of the research laboratory and of the increasing consciousness of industry's stake in society.

COMPETITION AND NEW INDUSTRIES

"IT IS ALREADY evident," says Dr. Harvey N. Davis, president of Stevens Institute of Technology, "that there is going to be in the post-war industrial world an unusual amount not only of inter-company, but also of inter-industry and even international competition. New industries, such as television and civilian radar, will be fighting for places in the industrial sun. New raw materials such as the light alloys and the plastics will be available to supplement or displace the more familiar materials of pre-war industry. New production processes such as hyper-milling, high-speed broaching, precision casting, and powder metallurgy will be competing with the more familiar machine-tools and process of pre-war production. All this welter of possibilities will necessitate a vast amount of industrial research if a firm or an industry is to remain or become prosperous. And there must also be intensive study of foreign lands both as markets and as sources of imports as a basis for post-war trade."

ROCKETS IN THE FUTURE

"WITH MILLIONS being spent in the development of jet-propulsion engines and airplanes," according to G. Edward Pendray, assistant to the president of Westinghouse Electric and Manufacturing Company, "we can no longer look upon rocket power as a dream of the future. It is already big business.

"New post-war industries will spring from this enormous war-time development of rockets, rocket motors, jet-propulsion planes, and gas turbines," continues Mr. Pendray, saying further that "the effect upon us, as civilians, will be enormous. Jet propulsion and rocket power will provide new altitudes, new velocities, new power for aircraft, and new devices as important and revolutionary to human life as the invention of the airplane itself. The gas turbine, close relative of the thermal jet engine, is maturing so rapidly that, in a very few years, we may see it driving planes, locomotives, ships, and electric generators."

GOVERNMENT AND RESEARCH

"THE JOB of normal peace-time research," says Hon. Robert P. Patterson, Under Secretary of War, "is a private job, not a government job. Those branches in which the government will continue in the principal role are well known: in no way do they conflict with the scientific functions of industry or university. What the government may do, if it is called upon, is to furnish information and financial support. It may furnish counsel, even leadership. It must not, in the normal researches of peace, assume control."

A NEW KIND OF INDUSTRIAL COMPANY

"I BELIEVE quite simply that the small company of the future will be as much a research organization as it is a manufacturing company, and that this new kind of company is the frontier for the next generation." So said Edwin H. Land, president of the Polaroid Corporation, speaking at a recent forum on "The Future of Industrial Research," sponsored by the Standard Oil Development Company.

"Internally this business will be a new type of social unit," continued Mr. Land. "There will be a different kind of boundary between management and labor. All will regard themselves as *labor* in the sense of having as their common purpose learning new things and applying that knowledge for public welfare. The machinist will be proud of and informed about the company's scientific advances; the scientist will enjoy the reduction to practice of his basic perceptions.

"Basic research" in these companies of the future, as visualized by Mr. Land, "will be so thorough that the equipment required for manufacturing will be light weight and automatic, requiring relatively small capital investment and relatively few operators. The essential technique for increasing the amount of work to be done during the next generation should be the multiplication of fields of activity rather than the multiplication of operators required in any particular activity."

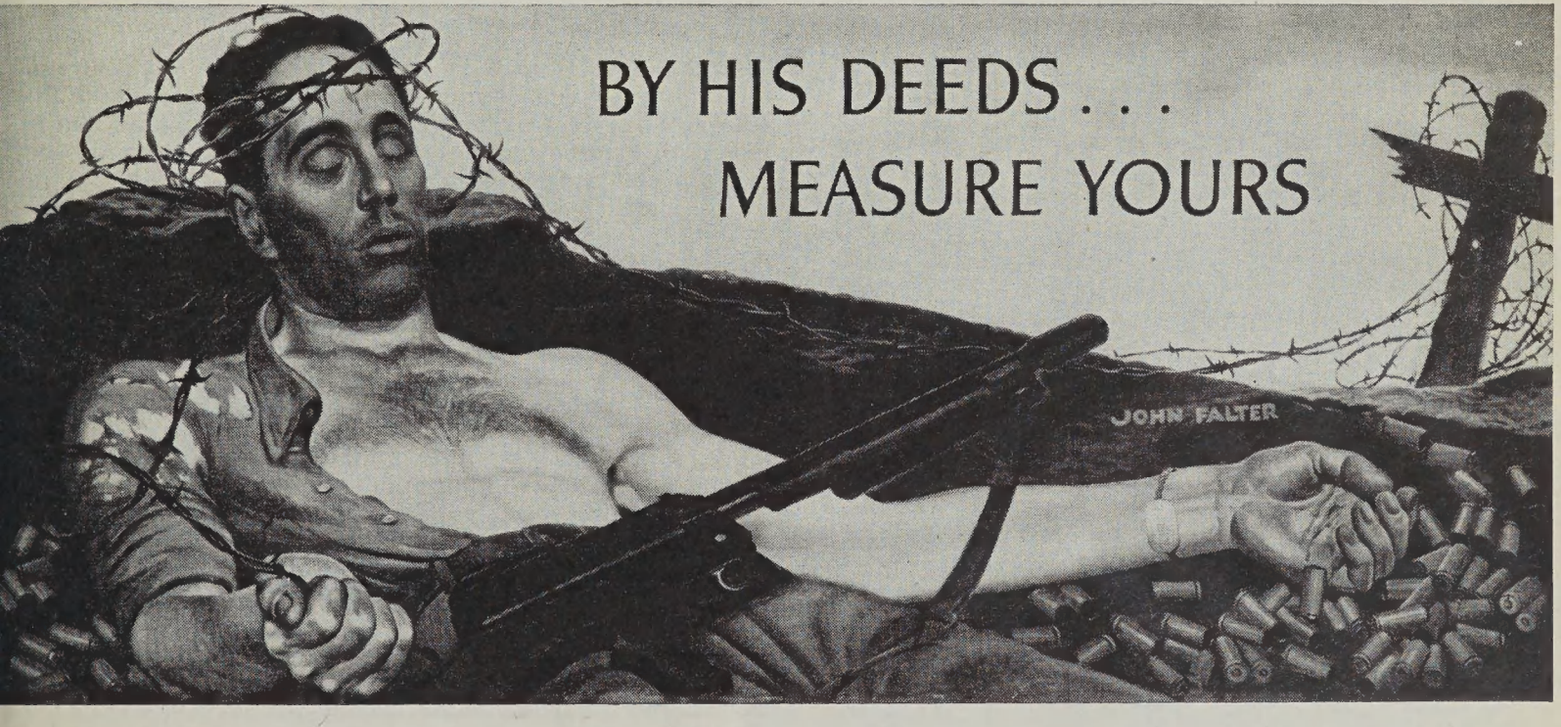
MANAGEMENT AND RESEARCH

"WISE MANAGEMENT," says Dr. Frank B. Jewett, retiring vice president of the American Telephone and Telegraph Company in charge of development and research, "will see to it that those who direct its research and development organization are an integral part of its policy-making group. Such participation imposes a grave responsibility on the directors of research and development. They must be more than able scientists and technologists—they must be industrial statesmen capable of viewing the problems and accomplishments of the laboratory not only as scientific achievements but as part of an economic and social structure. They must be capable of discarding work—no matter how interesting technically—whenever it is clear that it does not fit into that structure. On the other hand, they must be prepared to support to the limit those undertakings which they are convinced *do* fit into the economic and social structure, even though their less informed associates in management think otherwise."

SCIENTISTS ARE PEOPLE

IN DISCUSSING the oft-proposed thought that placing all industrial research under governmental direction would result in accelerated progress, Thomas Midgley, Jr., then president of the American Chemical Society said, just before his recent untimely death: "I have read the various Kilgore Bills and the arguments for and against; but I must confess that I simply cannot understand the logic involved. Somehow, it seems to me, the proponents of this and similar proposals assume that research scientists are going to work largely for the purpose of presenting the results of their labors to society free gratis, without any desire for rewards for themselves. It is quite true that scientists, as a group, are more willing to work for the sheer joy of satisfying their inquiring minds than are most other people; but it is also true that scientists have wives who want new automobiles and fur coats, quite like physicians' and lawyers' and judges' wives do, and scientists have children, just as other folks do, and scientists like to feel that they can raise and educate these children, like other folks do, and to do it they are deserving of an opportunity to obtain a financial reward that is somewhat proportional to the services they render society. I have never been able to figure out where they get it under the Kilgore proposal."

IT is not pleasant to have your peaceful life upset by wartime needs and restrictions and activities. . . . It is not pleasant to die, either. . . . Between you who live at home and the men who die at the front there is a direct connection. . . . By your actions, definitely, a certain number of these men will die or they will come through alive. If you do everything you can to hasten victory and do every bit of it as fast as you can . . . then, sure as fate you will save the lives of some men who will otherwise die because you let the war last too long. . . . Think it over. Till the war is won you cannot, in fairness to them, complain or waste or shirk. Instead, you will apply every last ounce of your effort to getting this thing done. . . . In the name of God and your fellow man, that is your job.



The civilian war organization needs your help. The Government has formed Citizens Service Corps as part of local Defense Councils. If such a group is at work in your community, cooperate with it to the limit of your ability. If none exists, help to organize one. A free booklet telling you what to do and how to do it will be sent to you at no charge if you will write to this magazine. This is your war. Help win it. Choose what you will do—now!

EVERY CIVILIAN A FIGHTER

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50 Years Ago in . . .

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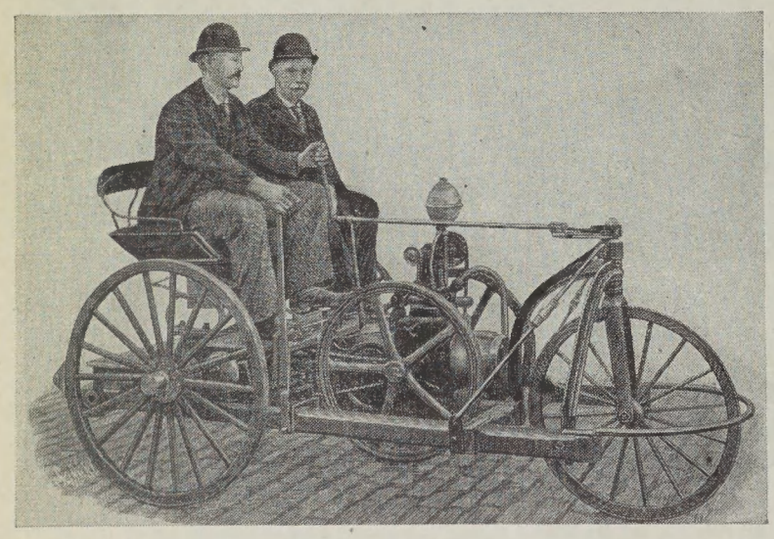
(Condensed from Issues of January, 1895)

PNEUMATIC TIRES — "An interesting series of experiments have been made recently to test the difference between the road friction of a carriage with and without the modern pneumatic-tired wheels. . . An obstruction 5/16 of an inch high was placed in front of each carriage, and it was found that 25 pounds was required to haul the steel tired carriage over the obstruction and but 11 pounds to draw the pneumatic tired carriage."

ANESTHETIC — "The fiftieth anniversary of the first use of anesthesia for the purpose of relieving pain was commemorated recently."

CANALS — "It has long been proposed to enlarge and generally improve the canal routes connecting New York with Philadelphia and Chesapeake Bay, and it now appears that this work is to be accomplished. . . The latest report of the surveyors of the Delaware and Raritan Canal stated that the full length of their proposed new route would be 32 miles. . . It is, furthermore, proposed to make connections with the Dismal Swamp Canal, and to widen and deepen this canal."

GAS ENGINE TRICYCLE — "The accompanying illustration shows the latest improvement in adapting the gas engine to the running of wagons on ordinary roads. This tricycle is



propelled by a two horse power Golden Gate balanced gas engine. . . It carries twelve hours' supply of gasoline, or two and one-half gallons, and can easily attain a speed of from ten to twelve miles per hour on favorable ground."

BUILDING CONSTRUCTION — "The Real Estate Record commented some time ago upon the immense reduction that has been made within the last decade, in the cost of building. Office buildings that cost $1.50 per cubic foot, and even more, can be produced by modern methods for 30 or 40 cents a cubic foot. This reduction in cost is due in no slight measure to the employment of mechanical devices in building operations. . . The employment of steam power in the mechanical operation of building has, however, by no means reached its limit."

HYDROELECTRIC POWER — "An ambitious plan for utilizing the waters of the Susquehanna River as a means of generating electric power is about to be carried out. . . It is proposed to dam the Susquehanna River near Conowingo, Maryland, and erect a large electric power house, similar to the one now in operation at Niagara Falls. The power obtained in this way will be supplied to Philadelphia, Wilmington and Baltimore, and other intermediate points. . . It is understood that the Westinghouse Electric Company are behind the project."

TIME SIGNALS — "Every day at noon a signal is sent to various parts of the country by telegraph, so that all operators and railway men who hear that signal can set their clocks at noon within two or three seconds. People who live near railway stations can thus get their time from it, and so exact time is diffused into every household of the land which is at all near a railway station."

ELECTRICITY — "The influence of electricity upon the vital forces of plants and of animals is not well understood. Its effect upon chemical changes and transformation is only partly comprehended. An electrical current destroys, disintegrates and decomposes. It also builds up, develops and perfects chemical combinations. . . The development of electrical science has been so rapid that an expert electrician would find it difficult to keep informed in regard to its new applications to industrial art in all lines. . . It has been recently discovered that caustic soda is cheaply produced by passing an electric current through a solution of salt."

COPPER — "The largest copper smelting property in the world is at Anaconda, Montana. During the past eleven years the magnitude of this plant and its results have been steadily increasing, till now the employes are numbered by the thousand, and the business aggregates over a million of dollars a month. . . From 1885 to 1892 inclusive the Anaconda Mining Company has extracted from the mines in Butte district over 450,000,000 pounds of copper."

TELEPHONY — "Despite its novelty, since the establishment of the first telephone lines dates back scarcely more than fifteen years, there are few industries of which we have had to record so numerous and so radical transformations as that of telephonic communications."

FISH FARMS — "The practice of raising food fish for market has become of late a very profitable industry, and in some parts of the country is being carried out on an extensive scale. The equipment of a fish farm, as it is called, is a very simple and inexpensive operation. Land which would be valueless for ordinary farming may be used for the purpose, the only requirement being a plentiful supply of good running water."

GRADE CROSSINGS — "The blindness of city officials to the great and daily dangers to which citizens are exposed by the practice of permitting street railways to cross the tracks of steam railroads at grade is becoming so serious a matter that some kind of a surgical operation seems necessary to restore their sight."

BICYCLES — "In cycle construction the reduction in weight has reached a startling point. Twenty-pound road wheels are plentiful, and the manufacturer who is carrying anything over 28 pounds is the exception and not the rule."

TELAUTOGRAPH — "The long-expected test of Gray's telautograph over the long-distance telephone line between Paris and London came off on the night of December 15, and resulted in a great success. . . The distance over which the writing was electrically reproduced was 312½ miles, and all agreed that it was a wonderful spectacle to watch in Paris the instantaneous reproduction of the movements of a pen in the hands of a man writing in London. Of the 312½ miles of line, 23 miles is submarine cable and 5½ miles consists of buried conductors at Paris. All of the English land line is overhead."

NEW RAILROAD CONSTRUCTION — "According to the records of the Railroad Gazette there has been much less railroad building in the United States during 1894 than in any year since the Civil War. Some 1,761 miles of new track have been laid in the year, which makes an addition of less than one per cent to the railroad mileage of the country, which at present is 177,753 miles."

WAR *STILL* NEEDS THE WIRES THIS CHRISTMAS



Please help keep LONG DISTANCE circuits clear for necessary calls on December 24, 25 and 26.

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What a boom we were handed by World War No. 1! Money came easily—went easily. Everybody was splurging on everything—from silk underwear to diamond sunbursts. Prices went skying. Sugar eventually hit 28¢ a pound!



Bye-bye, boom. Factories closed; men laid off. Prices and wages sinking fast. Wish we'd banked some of that dough we'd blown a few years back! With jobs scarce, that money would have come in mighty handy, then.



Prosperity. Stocks up fifty points in a week. Again everybody was buying everything—yachts, jewelry, stocks, real estate, regardless of cost. Depression? Phooey . . . we thought we'd found a way to lick depression.



Or had we? Bread lines, apple venders. WPA. "Brother, can you spare a dime?" No jobs. Prices dropping. Wages dropping. Everything dropping—except the mortgage on the house. "What goes up must come down."

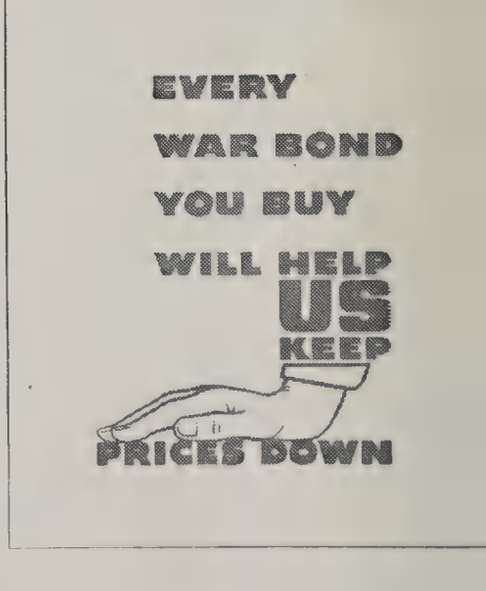


We're splurging again. Americans have been earning more money. But even today there are fewer goods to spend it on—so naturally prices rise. We must keep them in check. DON'T LET *IT* ALL HAPPEN AGAIN!

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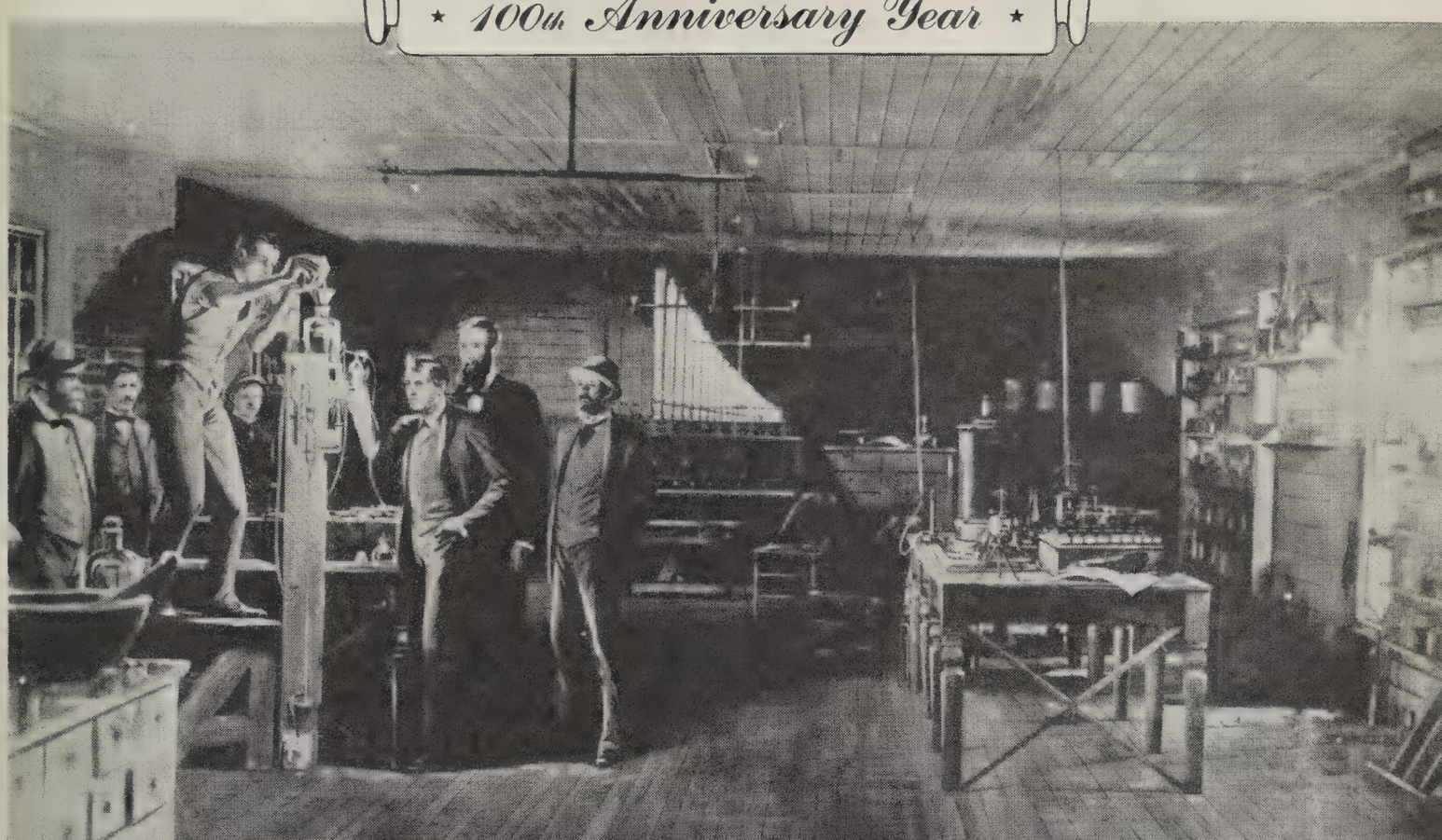
4 THINGS TO DO to keep prices down and help avoid another depression

1. Buy only what you really need.
2. When you buy, pay no more than the ceiling prices. Pay your ration points in full.
3. Keep your *own* prices down. Don't take advantage of war conditions to ask for more—for your labor, your services, or the goods you sell.
4. *Save.* Buy and hold all the War Bonds you can afford—to help pay for the war and insure your future. Keep up your insurance.



A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in co-operation with the Magazine Publishers of America

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From The Bettmann Archive
The dramatic moment when Edison's first successful electric lamp was lighted

Research Opens The Door

How Industry Has Developed the Philosophy of Research, Changing the Picture from that of the Lone Inventor Struggling Against Tremendous Odds to the Broad Teamwork Programs of Today. Present Applications of Industrial Research Point the Way Toward Solving Some of Tomorrow's Important Problems

By **CHARLES F. KETTERING**
Vice President of General Motors and Directing Head of General Motors Research Laboratories

IT WOULD hardly be fitting to begin an article dealing with the historical aspects of American invention and research without repeating Patent Commissioner Ellsworth's oft-quoted statement:

"The advancement of the arts from year to year taxes our credulity and seems to presage the arrival of that period when human improvement must end."

Ellsworth has been credited with making this observation in the year 1844. Inasmuch as he was United States Commissioner of Patents at that time, he certainly should have known whereof he spoke. Personally, in the face of this statement, I would have thought twice before embarking on the publishing of a magazine to be called "Scientific American"—that is, if I expected it to have a bright future. But, since Scientific American has been published without interruption for 100 years, it is obvious that Ellsworth overlooked some pertinent facts.

Let us take a look at Ellsworth's America from our vantage point of 100 years later and see if we are able to uncover some of the facts which led Ellsworth to make such a sweeping statement. Let us suppose, for example, that in the year 1840 or thereabouts we lived in Cincinnati and we wanted to travel to the heart of American progress—New York. Would we board a plane and arrive there in a couple of hours or so? No, indeed. To get there we would have to use canal boats, horsecars, steamboats, and the then new-fangled railroad. And it wouldn't be a matter of hours: it would take anywhere from seven to ten days, depending on the limitations of each mode of travel.

When we arrived in the metropolis, would we be amazed at the sight that would meet our eyes? There would be Broadway, for example, a street of three- or four-story houses—no office buildings or elevators in those days because people lived and conducted their business in the same buildings. On the street would be quite a few brightly colored horse-drawn buses—no taxis or subways. We would see a man drawing water from a well and taking it into



From The Bettmann Archive

Charles Goodyear discovers vulcanization of rubber

house, and the street-cleaning department apparently consisted of a drove of wandering pigs whose chief secondary function seemed to be getting in the way of the not-so-teeming traffic.

If we happened to look into one of the homes at night, we would find the only light coming from a whale-oil lamp or perhaps a gas fixture. The cooking in those days was all done in open fireplaces and on crude stoves, and all communication was by horse or shanks-mare.

As we look on these concrete evidences of "the advancements of the arts" to which Ellsworth referred, we can't help wondering just what he had in mind. People had been cooking in fireplaces for thousands of years and even the Romans had aqueducts—they didn't confine themselves to wells in the streets. The mail had been carried for centuries by the horse, which was almost as fast as the train or boat of Ellsworth's day. Where were these new things that indicated the end of human improvement?

Commissioner Ellsworth may have had in mind, as one example, Morse's telegraph, because it was in May, 1844, that the artist who tinkered with coils and batteries first sent over the wires from Washington to Baltimore the message "What hath God Wrought?" But I am pretty sure that Ellsworth didn't visualize at that time the Atlantic cable, Bell's telephone, Marconi's wireless, De Forest's electron tube, or television.

SETTING THE STAGE — That period of 100 years ago is one of the most interesting ones in the history of American invention. Things were beginning to happen all over the country that were destined to open the way for the tremendous American progress that was to follow. Up in Boston, Elias Howe had been working on a machine to sew seams mechanically to make clothes; in 1845 he entered his machine in a contest against five girls sewing by hand. Howe and his new sewing machine won because, as the judges said, his machine work was "neater and stronger."

A few years before, down in Connecticut, a bankrupt inventor by the name of Goodyear had smeared a piece of rubber with sulfur and left it lying overnight near a hot stove. It the morning he found the rubber had taken on entirely new properties; he had at last found the secret of vulcanizing rubber after a six-year heartbreaking search.

In 1847 a young man named Cyrus McCormick moved from Virginia to Chicago to set up a business there. Sixteen years before he had successfully demonstrated at the village of Steele's Tavern, Virginia, a machine that would mechanically reap grain faster than could be done by hand and with only a fraction of the labor. But it wasn't until 1840—nine years after he had invented the reaper—that he was able to sell one. By 1844 the McCormick homestead was a small industrial center, but McCormick moved his business to Chicago because he felt that the agricultural empire of the future would be on the plains.

Down in Kentucky, an ironmaster named William Kelly made a peculiar discovery when melting some iron to be used in casting maple-syrup kettles. He found that if a blast of air was blown through the molten iron, the carbon in the iron would burn itself out—in other words, the cold air would apparently heat up the metal. His young wife thought he was crazy and called in a doctor because every one knew you could cool coffee by blowing on it. But Kelly went on refining iron by this process and over in England, Henry Bessemer, who was working on the same process, invented the Bessemer converter. The age of cheap steel was born.

Looking back at that period, we now appreciate the fact that, simultaneously with the birth of Scientific American, men all over this country of ours were setting the stage for industrial America. Morse was laying the foundation for communication—McCormick was establishing the basis for our agricultural empire—Elias Howe was solving the clothing problem—Kelly had found a way to make cheap steel which, together with Goodyear's rubber and Col. Drake's oil, still to come, made possible the automobile industry that started some 50 years later.

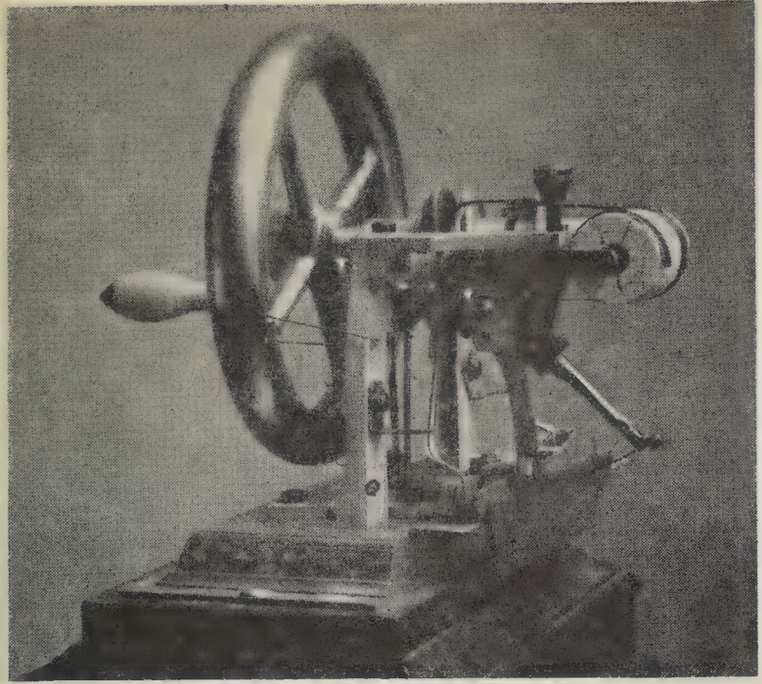
WHY MEN INVENT — It is interesting to note that these men were all individualists just as were Sholes, Mergenthaler, Bell, the Wright brothers, Hyatt, and many other of the early inventors. These men, I believe, invented for one of several reasons: the problem became a religion to them, like Goodyear's search for rubber; in the case of Howe and the sewing machine, there was a belief that the inventor would make a fortune; or, in many cases, the inventors had a great desire to do a certain thing, like the Wrights who "just wanted to fly."

All these inventors had their troubles—financial, inexperience, lack of facilities, and, in nearly all cases, an outstand-



From The Bettmann Archive

Otto Mergenthaler demonstrating the operation of the "blower machine," the first successful linotype, for Whitelaw Reid in the plant of the New York Tribune



Above: A working model of the sewing machine developed by Elias Howe and patented in 1846. Right: Howe, reproduced from an excellent daguerreotype

ing lack of sympathy and understanding on the part of their contemporaries. We must remember also that, in spite of Ellsworth's conviction that "the arts" were highly advanced, some of the basic facts of physics, chemistry, metallurgy, and thermodynamics were just being uncovered—they were almost starting from scratch.

But such men as these set into motion forces of great magnitude and complexity. The nation mushroomed. Transportation and communication became global. Great industries covered the country. Education became almost universal and science made important advances. The problems of the individual inventors were becoming more and more complex, were calling for new methods of attack. The entire pattern of American life was beginning to change. Along with improved transportation and communication came increased industrial output—and competition. And along with these changes we see a gradual change taking place in the method of inventing—the lone inventors, suffering hardships and making sacrifices, gradually became fewer in number.

It is difficult to state definitely just when this change started to take place. Some people say that Edison was the link between the old school and the new school of invention and research. Be that as it may, I believe Edison did make one discovery which was not assigned to him by the Patent Office. In carrying on his many investigations involving the electric light, the phonograph, and the motion picture, he found that whenever he uncovered a fact in any one of these new fields it was just as though he was opening the front door to a whole house of facts. Facing him were scores of other doors crying for opening and investigation beyond.

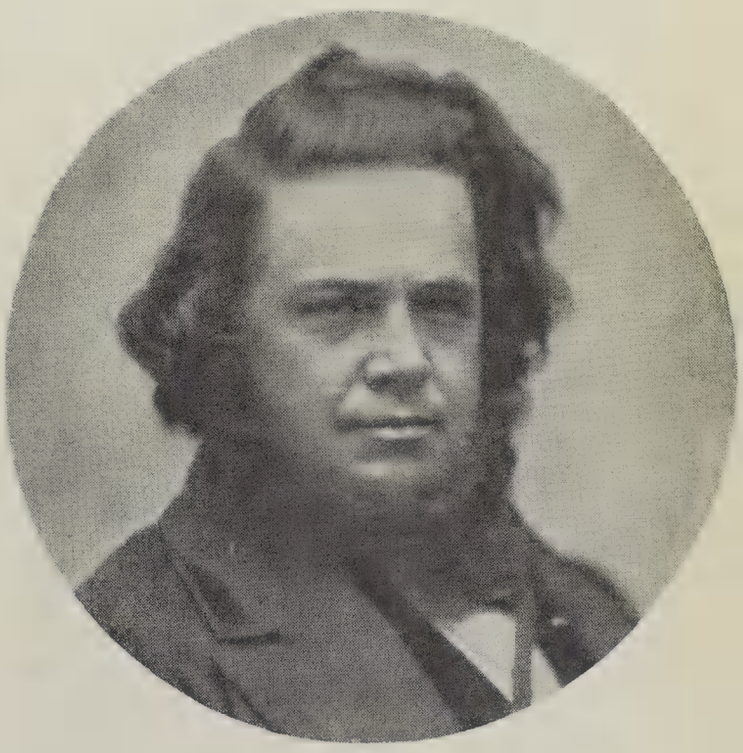
All of these unopened doors which he faced in these many fields forcibly impressed upon him the limitations of individual investigation. One man could not hope to explore all these channels in a lifetime. So he hit upon a logical solution: he would hire assistants skilled in each line of endeavor to open these doors for him and to explore beyond. The result was, as a friend of mine describes it "the 'drafting' room of 50 years ago grew into the engineering department which in turn gave birth to the research laboratory." Industrial research as we know it today was born of this revolution.

Along with the necessary developments of modern industry have come a multitude of problems that would completely baffle an inventor of the old school. To appreciate this fully, let us take as an example a single improvement that was made in the suspension system of the automobile some years ago—independent wheel suspension, better known to some, perhaps, as knee action. This, as we know, involved replacing the front axle and leaf springs, heritages of the old-time buggy, with coil springs held between individually pivoted arms or "wish-bones." This arrangement not only allowed each front wheel to move independently of the other but, more important, made possible the use of softer springs in front, thereby eliminating the uncomfortable "pitching" of the car when travelling over a rough road.

INVENTOR AT WORK — Now, it is quite conceivable that an idea such as this might originate with an individual (actually, the general idea is nearly 50 years old), but let's see what our lone inventor would have to do in order to have it materialize from the idea stage to the point where it becomes a feature of a standard car on the salesroom floor.

First he would have to do the paper work, as we call it. In other words, he would have to be a mathematician of a high order because the accurate calculation of spring rates, centers of oscillation, and so on, call for the generous use of mathematics. Then comes the matter of steering geometry, which means an accurate lay-out on the drafting board. But our inventor is a versatile man: he has worked this out and is now ready to build a model.

Since this model must be accurate in every detail, he had better be an A-1 tool and die maker with a well equipped machine shop handy, or be prepared to spend several thousand dollars to have it made. Let us assume he has crossed this bridge and that the model is ready for test. As is usually the case, it doesn't work, so he has to go through the whole thing again. Change this, change that. More time, more money. After doing this any number of times, the model finally acts as he planned it should.



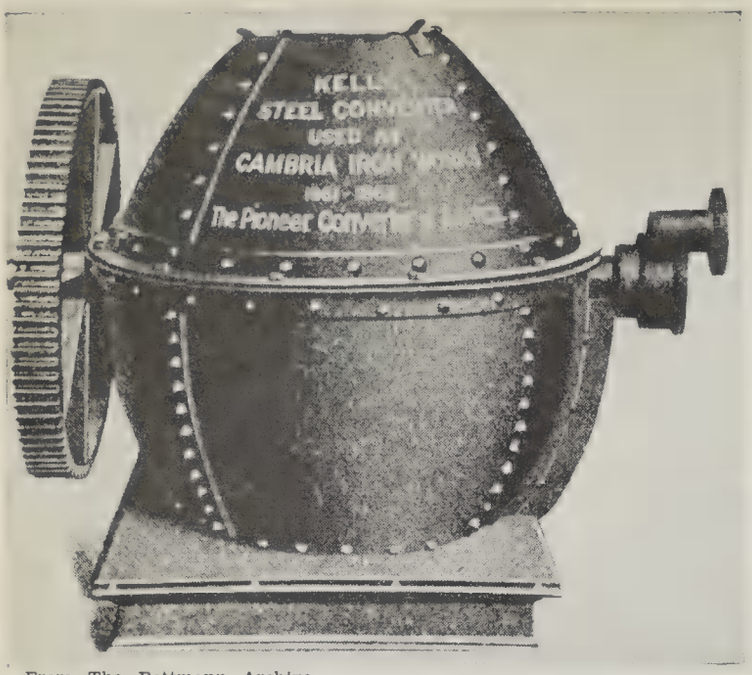
From The Bettmann Archive

But wait a minute; hasn't he forgotten something? Maybe someone else has had the same idea and it is covered by a patent! So he has a patent search made, which consumes more time and dollars and, if he is lucky, he finds the field is clear. So he has drawings made, and a lawyer draws up a patent application for him.

Now he has a model and has taken steps to protect the idea legally. It has taken time; perhaps a year or more has passed. But he is ready to make a working sample. So he selects a car which he feels would be suitable and proceeds to have the conversion parts made. His machine shop is inadequate for this larger work with its required forgings, castings, and so on. So he has to make new drawings, new calculations, and start at the beginning again. And that takes more time, more money.

Months roll by and he is ready for a road trial. But the working sample doesn't function like the model—a spring breaks, the wheels shimmy, or a hundred other things may happen and each one has to be ferreted out and corrected. To do this he has to be a metallurgist, a mechanical engineer, a mathematician, an optimist, and a very well-to-do man.

But we can readily assume that our mythical lone inventor is all of these, so the great day finally arrives when he is



From The Bettmann Archive

The age of cheap steel was born when it was discovered that air, blown through molten iron in the Kelly "steel converter" would burn out the carbon

to demonstrate his invention to the automobile company which he has in mind as the purchaser of his brain child. He proudly demonstrates the superior riding qualities of the "knee-action" car over a very rough road and awaits the reaction of the company's engineers. The engineers suggest that they return to the office at the plant; then they proceed to ask some very embarrassing questions such as: "How many thousand miles have you put on the suspension?"; "How does it work in hub-deep mud or water?"; "What is the effect of slush freezing on it in the winter?"; "What is your estimate of the additional cost of the new construction over the standard construction in car quantities of two million or so?"; "What is your financial proposition?"

Our friend is bewildered. He can only guess at the answers. The experienced engineers know that his estimates are far wide of the mark. But they agree that they should test the car on their proving ground in an attempt to try to find some of the answers. The results they eventually get are usually most discouraging to the inventor. If they find, though, that the idea has some merit, they make an arrangement with him and the whole repetitive cycle of design and test, production design and test, night and day, summer and winter, has to be gone through. This work involves scores of men—researchers, metallurgists, design engineers, chassis engineers, production men, test engineers, and lastly, the sales force.

There are many places for the inventor to become hopelessly lost in this process. He must have the faith of Goodyear, the creative ability of the Wrights, the patience of Edison, the business ability of Robert Fulton, the production knowledge of Ford or Knudsen—and, in addition, sufficient thousands of dollars to see the thing through.

METHODS HAVE CHANGED—Please don't misunderstand me when I paint this rather dark picture of the lone inventor's chances of succeeding in this modern world of ours. Don't get the impression that the chances of doing a new thing are impossible today. On the contrary, the chances are better than they ever were because we have a broader base upon which we can build. All I am trying to do is to point out that our methods of attack on the unsolved problems are quite different from those of a hundred years ago.

Perhaps I can better illustrate this fact by an actual example. Over 50 years ago Rudolph Diesel saw a Malayan fire syringe in a museum and hit upon the idea of using the same principle of compression-ignition as the basis of a new type of internal-combusion engine. After many unsuccessful attempts to apply the principle he at last produced a working engine. From the standpoint of thermodynamics it was a very efficient engine—in fact, the efficiency of the so-called Diesel cycle surpassed that of the Otto cycle commonly employed in the ordinary gasoline engine.

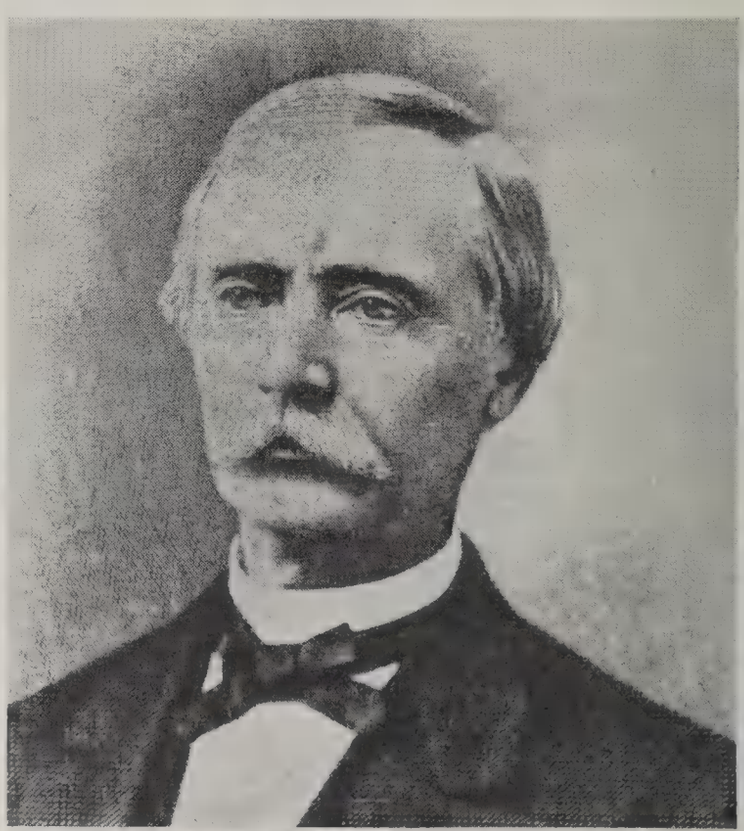
Unlike gasoline engines, however, Diesel engines were afflicted with several handicaps—they were large, heavy, and ran at slow speeds. In these respects they resembled steam engines more than gasoline engines. As a consequence, they were used principally in stationary power-plant installations and on ships. As time went on, the weight of the Diesels gradually came down as some of the structural features and materials used in the rapidly improving gasoline engines were incorporated in compression-ignition engine designs. But they still couldn't approach the gasoline engine on a power-weight ratio basis.

This was the situation in the 1920's when our research laboratories decided to take a fresh look at the compression-ignition engine. The first thing we had to do, of course, was to divorce it from the steam-engine and gasoline-engine schools of thought. We decided to attempt to design and build a compression-ignition engine like it wanted to be built and not like any other type of engine.

PRODUCTION DIFFICULTIES — To begin with, we started on the fuel-injection system, and after several years experimentation we arrived at the high-speed unit injector. Then we ran into the production fellows. The heart of the injector was the plunger which, in order to function properly, had to be fitted to the pump cylinder to an accuracy of a quarter of a tenth of a thousandth of an inch—less than one hundredth the diameter of a human hair. This is a far cry from the accuracy James Watt boasted of when he fitted a piston to a cylinder of a steam engine with a clearance of the thickness of a shilling. The production engineers threw up their hands, so we started our own precision injector department and solved that one.

In order to take full advantage of the compression-ingition cycle, we designed the new engine to operate on the two-cycle rather than the four-cycle principle. In other words, we would get a power stroke every revolution of the crankshaft instead of every other revolution. Theoretically this would give us twice the power from an engine of the same size. But this necessitated a blower to force in the fresh air. But this necessitated a new type of blower having spiral vanes. Again the production engineers were hesitant. So we had to develop at the same time a new machining operation. I bring out these points just to show how many angles there are to doing any new thing.

After these years of work we thought we had our problems just about licked but in reality we were just starting. This time it was the pistons which had a bad habit of seizing under the heat and high loads. So we began on the period of piston research and months and months passed

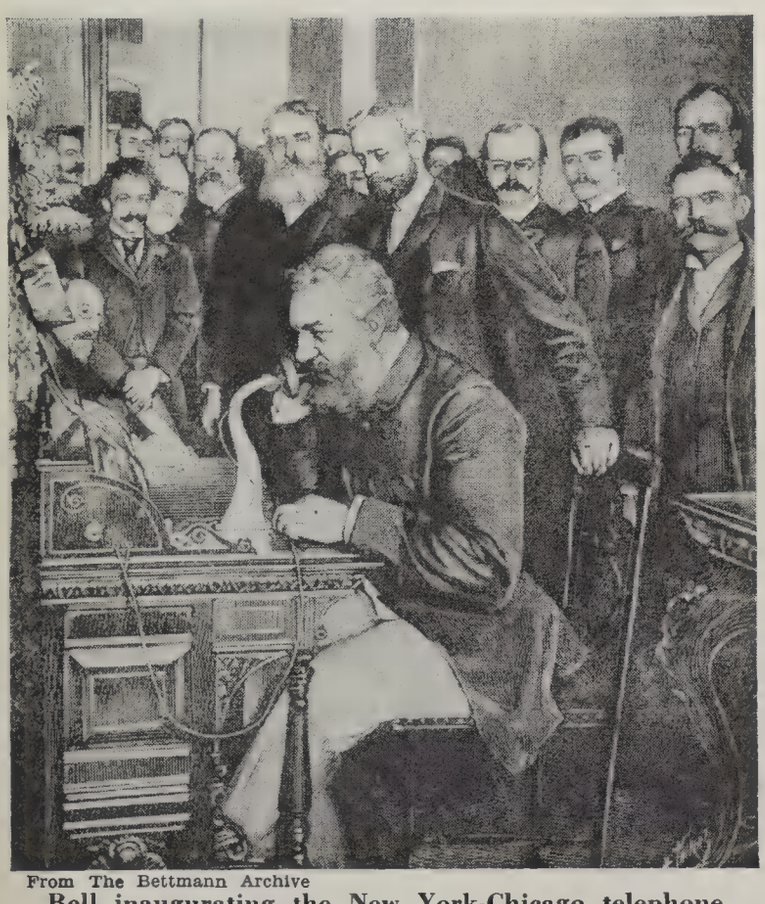


From The Bettmann Archive

William Kelly, inventor of the "steel converter"

However, after about 10 years of experimentation on the part of scores of engineers, designers, metallurgists, chemists, and production men—all working with every facility available, from electro-limit gages to dynamometers, milling machines, stroboscopes, and thermocouples—we had an engine to exhibit at the 1933 Century of Progress in Chicago. We ran it during the day and repaired it at night, but out of it all came a new, light, high-speed engine which the next year was installed in the first of the modern, high-speed, Diesel-powered streamlined trains.

MODERN RESEARCH GROUPS—The foregoing, I believe, gives a rough idea of how modern group research works. The man with the ideas, the man with the patience and persistence, the man with manual skill, the craftsman, and the man with ingenuity — each has his place in this picture.



From The Bettmann Archive

Bell inaugurating the New York-Chicago telephone line in 1892. Right: A view of lower Broadway, New York City, in 1889, showing the vast maze of overhead wires just before they were placed underground

Working as a group, they can do things that it would be practically impossible for them to accomplish individually.

From this little picture of a research project which I have given, you might draw the conclusion that the time, money, and effort expended is rather large just to get an engine for a streamlined train. But let's see what happened to that engine in the ten years after 1934. From the sleek, streamlined trains, it went into switching engines and then into freight service. A smaller version is being used in power generating units; it is being used also in both city and inter-city buses and trucks. On the water the use of the compression-ignition engine has spread in tugs and other boats. When World War II came along it powered submarines, and nearly all our landing craft, as well as many of our tanks and other heavy-duty land vehicles.

That is one thing that is certain: once a new idea is drawn out of oblivion, no one can predict just what will become of it or who will apply it to new uses. Take, for example, the case of F-12, or Freon. To get the background for this, it is necessary to take a look at the mechanical refrigerator at the end of World War I. It was in the kindergarten stage of development but we did recognize one fact about it. The gas refrigerant of those days had some very unpleasant properties: it was toxic and caused irritation and when the system sprang a leak in the home or in a hospital, the



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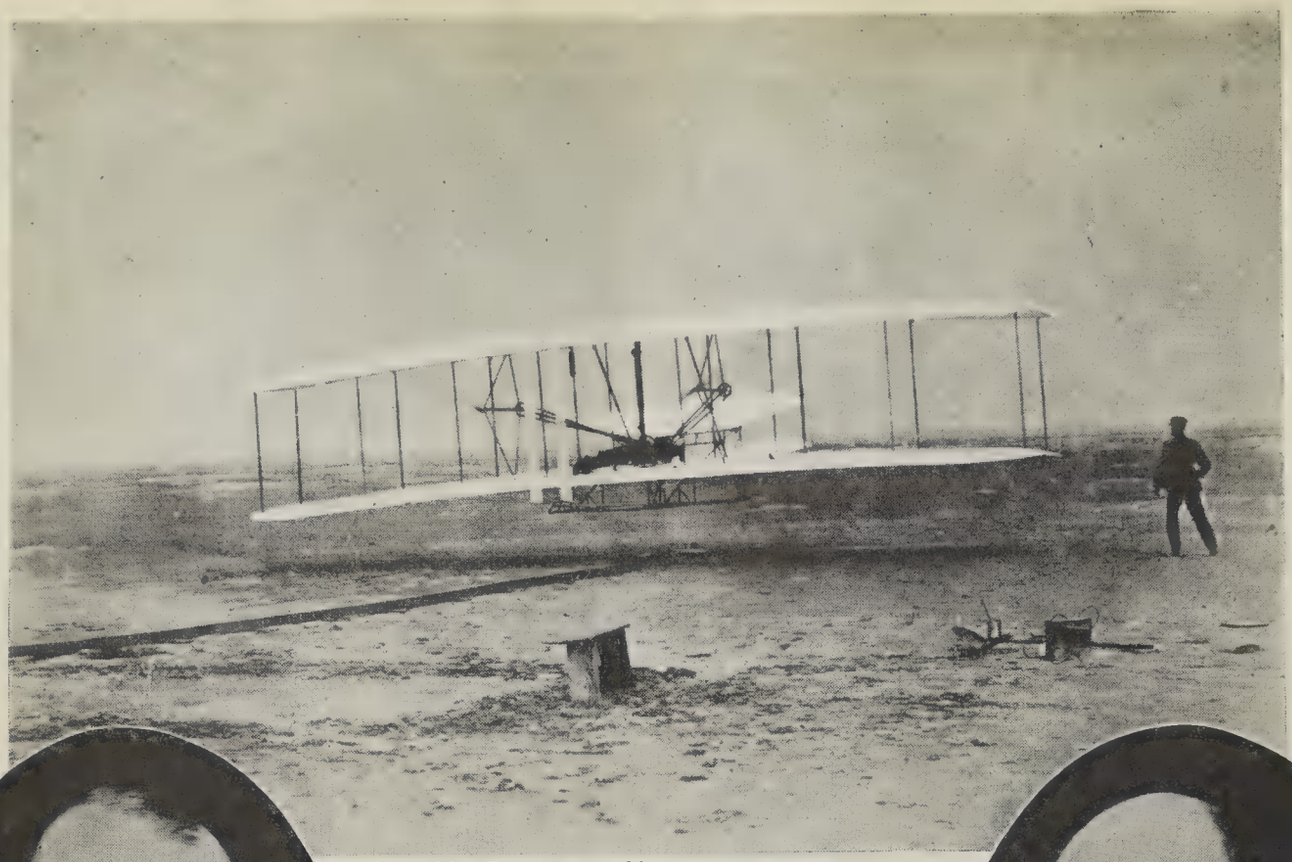
Rudolph Diesel, who saw a Malayan fire syringe

resulting effects could be quite harmful to human beings.

So our Organic Chemistry Department was assigned the job of doing something about this unhealthy situation. In other words, they had to find a new gas that would be non-flammable and non-toxic. After studying all available scientific tables and data it was found that only a few things would meet the specifications which had been set up, and that each one of these had some objections.

The most promising group of chemicals contained fluorine which, as every high-school chemist knows, has a bad reputation. Despite this, all the compounds were investigated in the hope that some fluorine compound could be found in which the bad qualities would neutralize each other. Thomas Midgley described this investigation in these words: "We





From The Bettmann Archive

At 10:37 A.M., on December 17, 1903, the first powered Wright plane soared over the sands at Kitty Hawk, North Carolina. The take-off was from a wooden track seen at the left. Orville Wright was at the crude controls; Wilbur Wright, on the ground, guided the plane by running along on the sand



Left: Orville Wright



Right: Wilbur Wright

plotted the boiling points, worked slide rules, brushed away eraser dirt and pencil shavings, and did all the other formalities that take the place of tea leaves and crystal balls in the life of a scientific fortune teller." After this had gone on for a long time, the search focused on one compound which, for simplicity, was called Freon.

To make this unusual compound, the research team found that in this country there were only five one-ounce bottles of the starting material which they wanted to use. One was selected at random and a few grams of Freon were prepared. A guinea pig was placed under a bell jar with it and, much to the surprise of a physician present, did not gasp and die—in fact it was not even irritated. When samples from the other four bottles were tried, the experiment did not work. By sheer luck the researchers had picked for the first experiment the only bottle containing a perfectly pure chemical.

As the result of the development of Freon, all risk of toxic harm was removed from household and hospital refrigeration and air conditioning equipment. But when World War II came along and our soldiers invaded the malaria-infested islands of the South Seas, Freon was called upon to do a new job. It was found to be the most effective carrier for the insecticide used to destroy the malaria-bearing mosquito. Still later it was also found to be a most efficient insulator for certain very important electrical equipment used by our armed forces.

Here, within the short span of less than 15 years, a gas designed as a refrigerant also plays the parts of an insecticide carrier and an electrical insulator—two uses which, by no stretch of the imagination, could possibly have been foreseen by the research men who originally produced it.

INVENTION AND RESEARCH—I believe that nothing better demonstrates the change which the world has undergone in the past century than a comparison of methods used by man in uncovering new facts a hundred years ago and today. Yet there is no sharp line of demarcation between Invention and Research, except for this distinction—Invention has to do with a specific result, while Research is concerned with the determination of those factors which may be necessary to the development of that result.

Today many people are confusing our geographical frontier with our mental frontier. When the first edition of Scientific American made its appearance, America was still a country of undeveloped resources, unexplored wilderness, and millions of uncultivated acres. Today these physical frontiers are practically gone and some people say we have no future —that we, as a nation, have reached our maturity.

But just as Morse, McCormick, Fulton, and Stevenson gave our forefathers the means of developing the frontier of a hundred years ago, modern science and research are putting into the hands of today's explorers the means of unlocking innumerable doors to undiscovered facts. It is easy to look back and marvel at our accomplishments of the past hundred years, but I had rather look ahead to the next hundred because there in the future the frontiers are limitless; or, to put it another way, as I have often said, there will always be a frontier where there is an open mind and a willing hand.

Better Metals Through Research

Outstanding War-Time Research-in-Metals Development is the Sharing of Data and Efforts by Manufacturers. The Inevitable Result is Better Materials and Methods for Peace-Time Products. These Will be Converted into Applications of Importance to Industry and the Public Alike

DESPITE all the dramatic records established by our metal-working industries in boosting the production of existing plants and expanding the capacity of whole industries by new building and the use of efficient production methods, the war-time metals development of most potential significance to this country is what has been learned about metals research. It is metals research that has made possible war-winning materials, and metals research that has laid the foundation for the conversion of those materials into peace-time applications of importance to the industrialist and the ordinary consumer alike.

This war evolved something heretofore unknown in our history—an integrated non-governmental organization for carrying out and correlating industrial research in metals that blueprinted our conservation, alloying, capacity-expansion, and new-product developments on a scale beyond anything our enemies have approached or we ourselves had previously imagined.

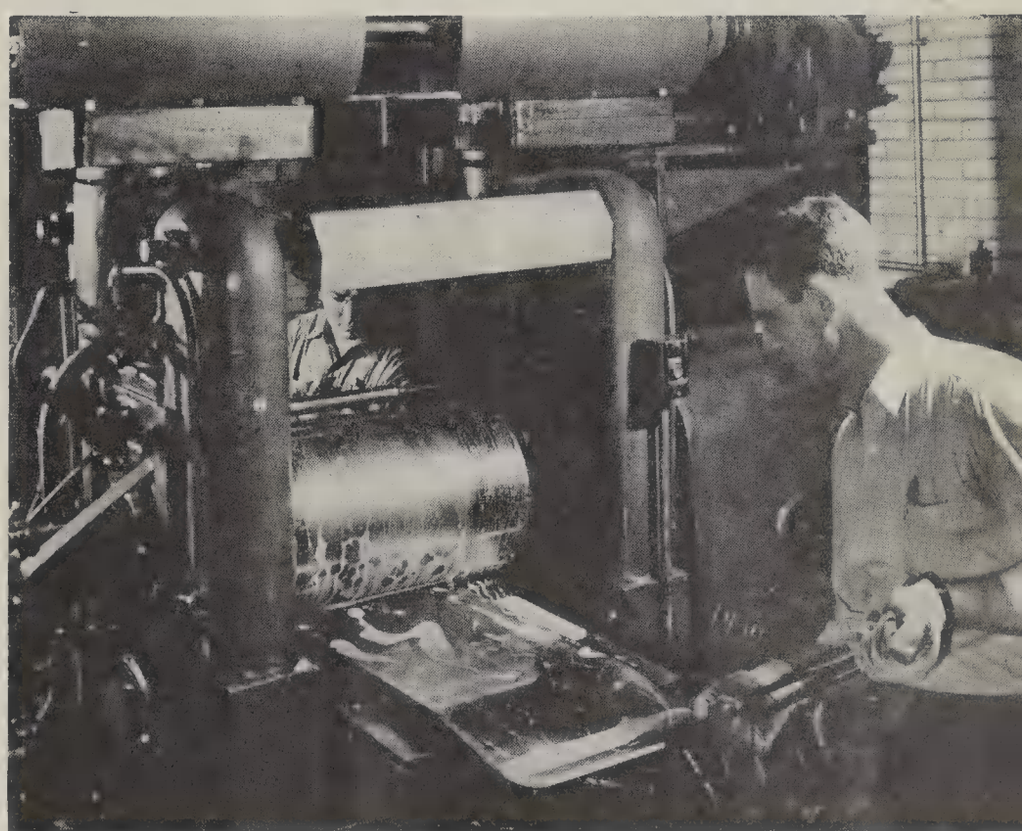
This organization, the War Metallurgy Committee, is a creature of the National Academy of Sciences and the National Research Council. It serves the functions of organizing and conducting specific research on metallurgical problems for the War Production Board. It also advises war-production agencies and the Armed Services on problems of conservation and use of metals and alloys. More than 100 research projects completed or now underway throughout the country are directed and supervised by the War Metallurgy Committee.

Without certain accomplishments of this group of metal researchers, victory in this war would not be possible, according to some authorities. Thus it was the War Metallurgy Committee that pushed the research that ended in the development of the low-alloy National Emergency steels, without which demands could not have been met for the large tonnage of alloy steel required for tanks, machine parts, aircraft equipment, motor vehicles, and so on.

The same Committee promoted the use of methods for making magnesium which increased production 300,000 tons or nearly 100-fold; it developed processes for making alumina from domestic bauxite or even from clay ready for use should the situation demand it; it supervised the planning and metallurgy of the only American tin plant to ease the tremendous pressure on our tin supply. In addition, it developed high-temperature alloys and precision manufacturing methods that made possible the efficient operation of turbo superchargers and gas turbines now in regular use on many of our high-flying heavy bombing planes. Other achievements of the Committee were to work out countless processes for making a little metal go a longer way, for speeding the production of badly needed metal products, or to permit use by the Armed Services of non-critical materials once considered incapable of munitions application.

The chairman of this committee is Clyde Williams, Director, Battelle Memorial Institute, (itself a metals research organization that has grown astonishingly during the war); the vice chairman is Dr. Zay Jeffries, Technical Director of General Electric's Lamp Works and one of the fathers of scientific metallurgy in this country; the members include dozens of metallurgists and engineers in industry, colleges, and research institutes. But more important than who is on the committee is the fact that it represents a bank of metallurgical know-how in which is deposited, without fear of competitive advantage, the full store of metallurgical knowledge accumulated in recent years by our research staffs and out of which is drawn their tested technical knowledge and experience, for the most efficient use of materials in munitions.

PURE AND APPLIED RESEARCH—Not all the research on metals conducted for war purposes has been under the auspices of the War Metallurgy Committee, but the committee has had its irons in so many fires that it is difficult to determine where its inspirations and activities begin and end. In the vast panorama of war-time research in metals, the

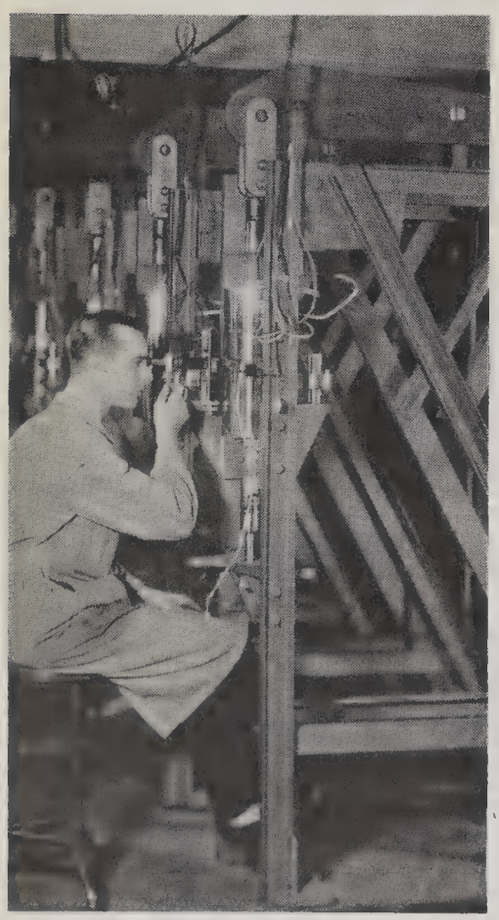


Rolling an experimental alloy ingot at the Aluminum Research Laboratories

strongly scientific or pure theoretical aspects have been pushed into the background. Practical research, nevertheless, is certain to unearth many data that eventually will be utilized by the pure scientists when they return to their academic pursuits.

Similarly, the products of this war-time research have direct peace-time implications. The high-temperature materials mentioned previously will make possible a new gas turbine industry which will eventually supply units for transportation and other equipment in what is now the established domain of Diesel and gasoline engines. The work on aluminum from low-grade domestic ores means that the development of light-metal applications may be continued without fear of an eventual loss of raw material supply. The precision casting methods evolved for the manufacture of supercharger blades, buckets, and so on, will be applied in the post-war period to the manufacture of countless intricate parts to close tolerances on a mass-production basis.

MATERIALS—In the field of materials, recent research in metals has evolved new aluminum alloys, much stronger than anything available before the war and combining qualities of strength and corrosion-resistance certain to find broad peace-time use in aircraft, railway cars, busses, automobiles, and even machinery of certain types. Systematic studies of beryllium-copper have resulted in methods of treating and working this material that make it best for many kinds of fine precision springs. Research on the effect of low temperatures on metals has not only given better materials to withstand the embrittling effects of sub-zero temperatures on aircraft parts but also provided information on how to improve tool steels by refrigerating them during their heat-treating cycles—the last a development that should save American industry thousands of dollars in its machining operations in any post-war year.



Creep tests being conducted in the research laboratories of the United States Steel Corporation. Such tests as these are part of the development program that has given rise to new heat-resistant alloys for gas turbine and supercharger components

METHODS—Nor has research on metal-working methods lagged. Industry-wide coördinated research attacked the problem of producing steel cartridge cases that would perform satisfactorily in place of brass. The real sticker was the drastic forming operation. Research finally licked it through suitable modification in the conventional deep-drawing steel, and painfully developed heat-treating and forming methods. The result was enough steel cases to relieve the pressure on brass during the most critical shortage period of the war. And the practice that war-time research has evolved will permit the post-war manufacture, once considered impossible, of drawn parts in steels as strong as those that can now be used.

Similarly, the heat treatment of steel has been the subject of a vast amount of research replete with peace-time potentialities. The most important of these researches, reviewed in the December, 1944, issue of Scientific American, include the development of drastic quenches to bring out the full hardness of steel with a minimum of alloy—a combination that reconversion engineers are already planning to utilize for technically controlled mass-production of low-cost machine and engine parts, general hardware, and so on; isothermal treatments to permit the crackless and distortion-free hardening of irregular-shaped parts; electronic induction heating to provide ultra-thin hardened cases without carburizing; and many others.

Modern research in metals has increasingly centered around certain causes of failure or service problems whose solution will vastly enhance the performance of metals in many situations. Those conditions that have received most attention are creep of metals or gradual flow under sustained stress; the fatigue of metals or their failure in vibration at relatively light loads; corrosion of materials in marine, industrial, or just ordinary environments; and the wearing away and galling of bearing surfaces.

These researches have been in some cases spectacularly successful. Here, for example, is the telescoped story of the fatigue-of-metals problem and its practical solution based directly on research. The preoccupation of a small group of men with the conditions that hasten the failure of auto and railroad axles, compressor shafts, bearings, reciprocating machine parts, bridge cables, and so forth, gave, first, dependable methods of testing the endurance of metals. These in turn helped a larger group of engineers to understand the importance of improved endurance; of avoiding surface discontinuities and roughnesses, sharp concentrations of stress in service, and the like; of designing for dynamic balance; and of prestressing or otherwise placing the outer metal layers of a metal part in a state of compression.



A pilot plant at Jones and Laughlin Steel Corporation includes a 375-pound electric melting furnace used to prepare test heats of steel

Finally, practical methods such as the prevention of decarburization of steel (which hastens fatigue failures), the superfinishing of parts to "roughnesses" measured in micro-inches, the use of balancing machines and techniques to locate and correct fatiguing unbalance in rotating parts and—most recently—the application of shot-peening blast treatments to cold-work metal surfaces, were developed and are now widely used to combat fatigue failures or to increase the loads that a product can withstand indefinitely under vibration, without failure.

THREE SIMILAR STORIES—The stories of creep, corrosion, and wear research are similar. Creep studies produced the high-temperature alloys previously mentioned. Corrosion work has tremendously increased the utility of many alloys by showing what corrosives and what "galvanic couple" combinations should be avoided, and has stimulated the development of more corrosion-resistant alloys and of durable protective coatings.

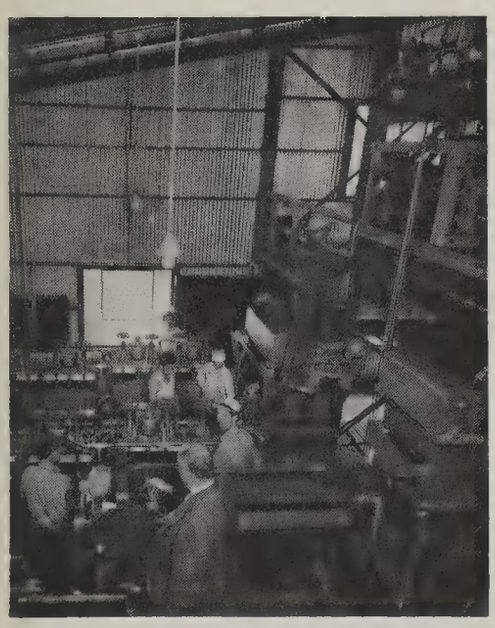
Bad boy Wear and his father, Friction, are currently undergoing some of the most intense investigation. Bearing-wear problems were usually attacked empirically—by trying various bearing-shaft combinations, bearing alloys, lubricants, operating conditions, and so on—until the best set-up was evolved. Now the scientific brains of the automotive, railroad, oil, and bearing alloy manufacturers are probing the abstruse realms of intermolecular forces and behavior for the secrets of metal-to-metal wear.

The outcome is certain to be longer-lived bearings for hundreds of uses and therefore more efficient machines and engines, plus a host of by-products. Already recognized as a related development is the new technique of high-speed milling of steel, the direct result of coördinated research on the mecha-

nism of wear in metal-cutting operations. A well-known manufacturer of friction parts (brake disks, clutch faces, and the like) made by powder metallurgy has decided that a scientific investigation of the nature of friction between metals would not only help his own product development but might illuminate the whole field of powder metallurgy, which is itself engrossed in the consideration of particle-to-particle bonds from other points of view.

TOOLS OF RESEARCH—Many research tools of relatively recent development have been essential factors in the accelerating pace of metals research. The electron microscope, capable of magnifying metal structures 100,000 times, will hasten the development of new, highly hardenable steels and alloys, and will solve many research problems in powder metallurgy. X-ray and electron diffraction help us to understand the atomic structures of metals both far below and exactly on metal surfaces. Electronic micrometers permit the measurement of tiny movements in delicate specimens without imposing an extraneous load from the instrument—a valuable contribution to spring research and to studies on the cold flow of metals within the "elastic" range.

Hardness testers that measure the hardness of microscopic areas of metal surfaces, ultra-high-speed photography



Part of the flotation unit of a manganese-production pilot plant, operated by Bureau of Mines in Nevada

for studying metal-to-metal impact behavior, and photomicrography in color are but a few of the new weapons of the metallurgical scientists in their campaign for better materials and methods.

Metals research men look for no end of problems for them to tackle in the months and years ahead. The coming competition among materials will be preceded and fanned by intensive alloy development and announcements of new products of alloy research. Among the still unsolved problems or those now undergoing study are the discovery of brazing alloys that melt somewhere between the 700 degrees, Fahrenheit, of the highest-melting soft solder and the 1100 degrees, Fahrenheit, of the low-melting silver brazing alloys; the development of corrosion-resistant or stainless steels that machine as easily as screw-stock; the establishment of important uses for magnesium powder aside from pyrotechnics; the economical production of iron or steel parts by powder metallurgy that have mechanical properties comparable to those of the strongest cast, forged, or rolled steels; and that old perennial, the low-cost manufacture of aluminum from clay.

Writing recently in *Metals and Alloys*, Dr. Jeffries declared that "the most important metallurgical engineering development of the war is the opening up by industry of its great bank of metallurgical know-how to competitors and non-competitors alike with little regard for post-war consequences." Actually those post-war consequences are certain to be better materials and methods for all of industry and better peace-time products for the ultimate consumer.

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MAGNESIUM POROSITY

Being Corrected by Use Of Organic Impregnants

POROSITY exists in magnesium alloy castings, as in other metals, to varying degrees, depending on alloy composition, casting conditions, and gas content. An unavoidable feature of magnesium aircraft castings, porosity is being widely corrected in that field on a production scale by impregnating the castings with specially developed organic compounds in an autoclave after extracting air from the pores by a vacuum treatment.

Originally sodium silicate was used and then tung (or China-wood) oil, until the supply of the latter available for this use disappeared. The compounds that are nicely filling the gap, with results promising their continued use when tung oil returns from the wars, are alkyd resin fatty acids, modified by and reacting with monostyrene.

From a cost standpoint the old and the new materials would be approximately on the same level. Castings impregnated with the new compounds have successfully withstood pressure tests of 1000 pounds per square inch and treated aircraft-engine cylinder heads have passed service tests of more than six months' duration, according to the records.

SHOT PEENING

Improves Mechanical Properties of Metals

AMONG metal-working's fastest-moving trends is the growth in use of the shot-peening process, whereby the surfaces of steel parts are bombarded with metallic shot to improve the mechanical properties of the parts, especially in vibration service.

Peening is a cold-working operation that produces a shallow layer of surface metal which is harder, stronger, and less ductile than the underlying metal. The chief advantage of shot peening is that, through the formation of this surface layer of metal in a state of compressive stress, it increases the "fatigue strength" or "endurance limit" (resistance to cracking or breaking in repeated-stress or vibrational service) of the part and either lengthens its life or permits the use of heavier fatigue-loads than can be used with unpeened parts.

To a certain extent shot peening can replace heat treating or surface hardening if distortion must be avoided. It is being applied to finished parts, such as springs; to specific areas, as fillets on structural or machine parts; and to the bodies of shafts to resist pitting-corrosion or "corrosion-fatigue." Shot-peened gear teeth have improved resistance to pit-corrosion and to wear. It has also replaced polishing, for shot blasting has long been used for cleaning parts. Furthermore, the blast intensities used for peening have a distinct polishing effect.

The machines used are similar to those conventionally employed for blast-cleaning by the shot method, the shot being thrown against the work by compressed air blast or, without air, by centrifugal means. They usually embody automatic and conveyorizing features for incorporation in mass-production systems.

STRONG ALLOY

Made With Aluminum, Magnesium, Zinc, and Copper

RECENT months have seen the introduction to industry of two new strong aluminum alloys—75S of Aluminum Company of America and R301 of Reynolds Metals Company. Now a third has appeared, also of outstanding interest to post-war designers and materials engineers.

After nearly two years of laboratory tests and development of fabricating processes, "the strongest aluminum alloy yet available for commercial use" was recently announced by Mr. Paul P. Zeigler, Reynolds Metals Company chief metallurgist.

This aluminum alloy, known as R303, is made with magnesium, zinc, and copper. It is described as the first combination of this type to possess such strength and at the same time to be free of defects—susceptibility to corrosion and stress cracking—which for years have made similar alloys impractical for use in the construction of aircraft.

The new alloy has almost three times the compressive strength of structural steel. Tests have shown this alloy to be over 50 percent higher than structural steel in tensile yield strength and 70 percent stronger than the other older type high-strength aluminum alloys.

When peace comes, the new alloy will be available for railroad equipment automotive parts, and heavy machinery as well as for baby carriages, furniture and appliances and other light household articles.

Railways Roll On Research

Many Problems Became the Subjects of Research Early in the History of the Industry. Some of These Have Been Under Almost Continuous Investigation Since. Practially No Industry Employing Research in the Development of its Products Has Not Made its Contribution to the Railways

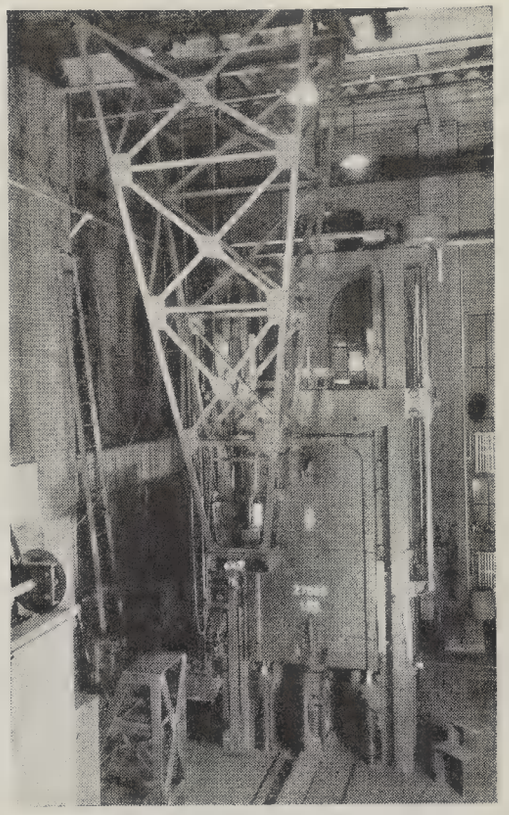
THE RAILWAYS of America have been the beneficiaries of a greater variety of industrial research extending back over more years than perhaps any other industry in America. Indeed, there are few industries whose research development has not contributed to railway progress, for the reason that railroads are large purchasers of the products of almost every industry.

Why has the physical progress of the railways depended so largely on sources outside themselves? Because the railways are a service industry and produce no physical product for sale. Furthermore, through most of their history the unsatisfied demands for capital to improve and expand facilities involved directly in the conduct of transportation have left little opportunity for the railroads to undertake the development of manufacturing facilities that would supply their own needs. Consequently, they have provided a large and diversified market which enterprising manufacturers have not been slow to exploit.

This has resulted in the development of the so-called railway supply industry which includes locomotive and car builders, manufacturers of couplers, draft gears, freight-car trucks, car wheels, brake shoes, locomotive superheater and feedwater heaters, locomotive boosters, and air brakes. It also includes firms that manufacture special power and control equipment for passenger-car lighting and heating, as well as track fastenings, ballast-cleaning equipment, power tools for track maintenance, and manufacturers of many other specialties for locomotives and cars, and even special shop tools for their repair. All these manufacturers employ industrial research in some form, many in their own laboratories, for the advancement and improvement of their products.

But this does not mean that the railways themselves have not been engaged in research. Indeed, some of the earliest industrial research conducted in the United States was initiated by the railroads. In cases where they did not conduct it directly, they nevertheless inspired and guided it. In fact, since shortly after the Civil War such projects in increasing number have been a continuous factor in the business.

RAILROADS BEGAN EARLY—One such investigation reported at the 1875 meeting of the American Railway Master Mechanics' Association was a series of drop-hammer tests of iron and steel axles conducted in a Philadelphia shipyard. The results showed that steel possessed superior stiffness and endurance. Indicative of a pattern which has been repeated many times since, the services of the physical testing laboratory at the Stevens Institute were utilized in determining the physical properties of specimens of the material in the axles tested.



Drop-test set-up in the draft-gear laboratory of the Association of American Railroads at Purdue University

In 1873 a committee of the Master Car Builders' Association arranged a competitive trial of the Westinghouse automatic air brake and the Smith vacuum brake. A year later the committee set forth a specification of what then seemed to be required of a perfect power brake. After further study and testing, the Master Car Builders' Association eliminated other brakes and, following the famous Burlington tests of 1887, the air brake became the standard for freight trains as well as for passenger trains.

The railways themselves were less directly responsible for the industrial research involved in the development and improvement of braking than in formulating requisites and stimulating progress by the manufacturers. Because the brake is an important factor in the safety of train operation, the government, through the Interstate Commerce Commission, has also influenced the direction which brake investigation has taken. After hearings on its own initiative, ordered on February 20, 1922, the Commission set forth a specification of functions which in its opinion were required by a freight brake to control safely the speed of long, heavy trains. Appliances created by the air-brake manufacturers to meet the Commission's specifications were investigated by the railways on the 150-car test rack of the American Railway Association at Purdue University. Those possessing sufficient merit were then given road tests on 150-car trains.

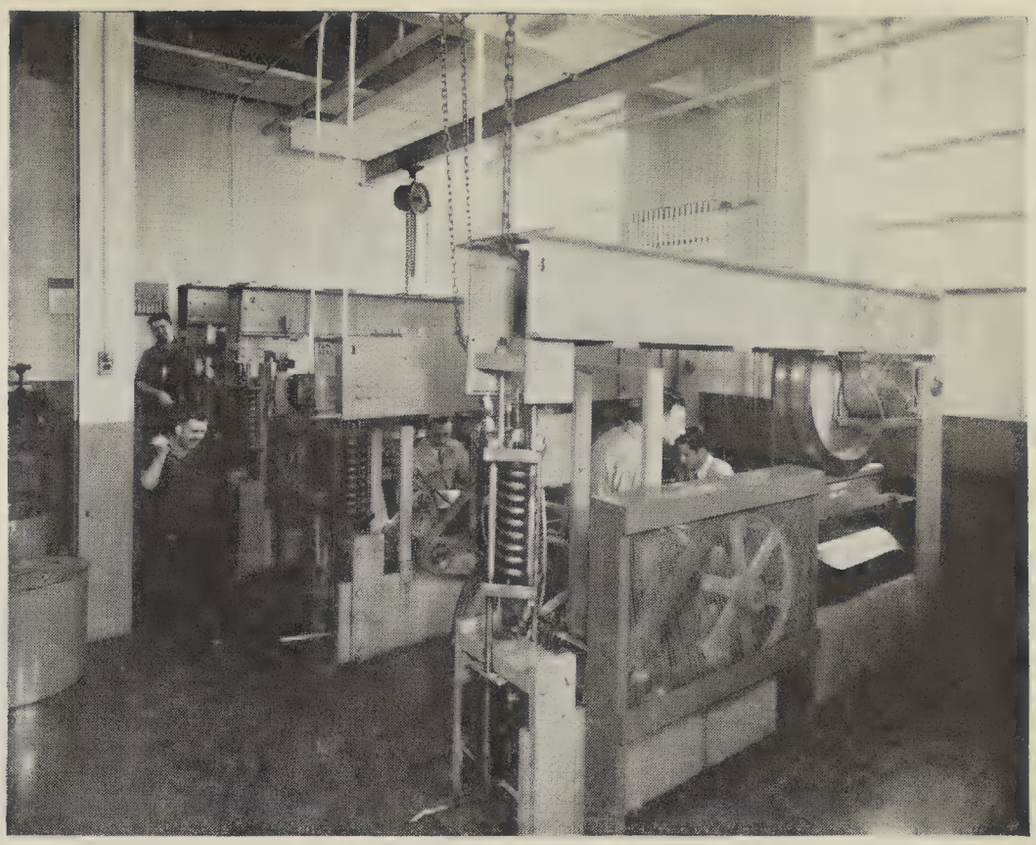
This project was placed in charge of a director of research appointed by the American Railway Association in 1924. The road tests were completed in March, 1931. The commercial brake developed by the manufacturers has now been installed on about half the freight cars of American railroads. Functioning interchangeably with the much simpler and less effective brakes which it supersedes, it has greatly improved the safety of long-train operation.

These examples are only suggestive of the pattern of research contributing to the advancement of railway transportation facilities. There is a long list of additional car and locomotive devices which industrial research has helped to establish, improve, and refine. Here are a few of the items. There is the friction draft-gear on which a large amount of work has been done by the Association of American Railroads in its draft-gear testing laboratory at Purdue University, in addition to the research by the manufacturers in their own laboratories. Chilled-iron car wheels are the product of many independent foundries having regional markets. The chilled wheel has been the subject of a continuing intensive research conducted by the Association

of Manufacturers of Chilled Car Wheels. Its studies cover metallurgy, design, and manufacturing processes, and have resulted in a uniform high-quality product.

The improvement of wrought-steel wheels has also involved extensive research, guided by the Technical Committee of the wheel manufacturers. The work has been done in the laboratories of the individual manufacturers. Car couplers have been the subject of almost constant study ever since the vertical-plane coupler was adopted in 1887. Cast-steel freight car trucks have been subjected to a large amount of research to improve the distribution of the metal to resist the stresses to which the castings are exposed and to improve their quality.

No account of the agencies which have been engaged in research for the benefit of the railways would be complete which did not cite the locomotive test plant of the Pennsylvania Railroad at Altoona, Pennsylvania. This plant, which was first installed at the St. Louis Exposition in 1904 and thereafter moved to its present location, has been utilized through the years for the conduct of a large number of complete locomotive operating tests in which accurate data on fuel consumption, steam production, cylinder horsepower, and drawbar pull were recorded, along with a large amount of data pertaining to the internal functioning of the locomotive. Additional studies were made of the effect of specific changes in locomotive proportions and design. The data from these tests are an important part of the working library of the steam-locomotive designer, and they have guided many an inventor of locomotive improvements.



Rolling-load machines used in testing rails at the University of Michigan

ROADBED AND TRACK—The track rail has been under constant development from the very beginning of its use as a path for wheels, even before steam power was adapted to railway use. The first organized attack on the problem of rail design and manufacture was undertaken in 1887 by the Roadmasters' Association of America. In 1897 the American Society of Civil Engineers brought to the research the scientific knowledge needed to carry it to a conclusion.

Since 1900, when the American Railway Engineering Association was organized, many phases of track and roadbed construction have been under investigation. When the amount of open-hearth steel rail in use was increased, rail failures began to occur with no previous warning. The cause was determined to be transverse fissures within the rail. While working with the rail manufacturers to control the cause, the committee in charge undertook to find some means by which these fissures could be detected before breakage occurred. A number of independent investigators also undertook the solution of this problem.

None of these efforts proved successful. The committee, backed by the American Railway Association, asked the late Elmer A. Sperry to undertake a program of research to perfect a dependable device for locating fissures.

The results were all that could have been desired, and now periodical checks of track rail by the use of rail detector cars are carried out on many railroads. The device finds and records fissures and other defects even in the incipient stage.

In the meantime, the railways and the manufacturers undertook to finance jointly an extended program of research to determine the cause of the fissures and what measures could be taken to avoid them. This project, started at the University of Illinois in 1933, discovered that transverse fissures were caused by the rapid cooling of rails on open racks at the rolling mill. Controlled cooling in enclosed boxes has substantially eliminated this hazard.

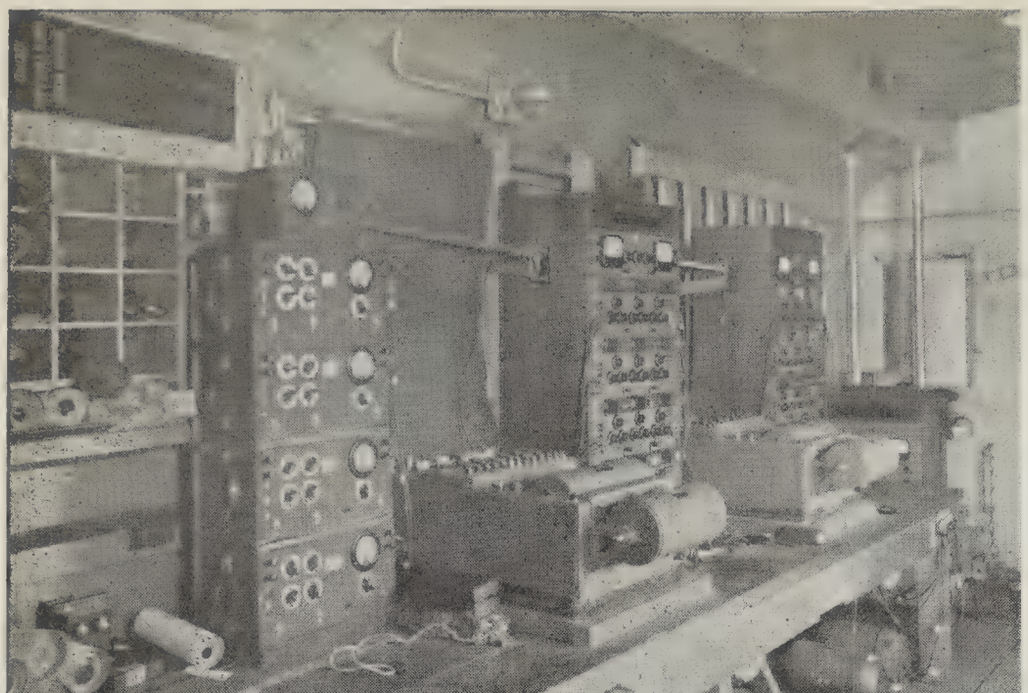
The railway tie, a simple stick of rough timber, has been the subject of research which began within a few years after the first railroads were built in America. Out of this continuous effort to increase the life of ties was born the wood-preserving industry. From the four or five years' use which could be obtained from ties of natural timber, the service life of treated ties has been increased to 25 or more years.

SIGNALS—The track circuit is the basis of automatic block signaling. Methods for its control, and its power supply, have been subjects of constant study for many years. Another important factor in extending the use of automatic block signals was the improvement in lighting; first to provide color indications at night and, later, light signals suitable for day as well as night.

One of the most outstanding steps in the signaling fields is automatic train control on which extensive research has been conducted since the Interstate Commerce Commission ordered installations on 49 railroads in 1922. The continuous inductive system, which does not depend upon impulses received at wayside signal locations for its functioning, also led to the development of cab signals which bring the signal indication into the cab where it is constantly in the sight of the engineman. Incidentally, the need of glass in colors other than red and green, so that it would be unnecessary to use white as a "clear" signal, led to research by glass manufacturers which produced a yellow glass that could be clearly distinguished from red.

An important facility which has been developed by the signal manufacturing companies is the car retarder, an electro-pneumatically operated device installed in the track by which the speed of cars in hump classification yards can be controlled at selected locations by one man in a tower. This dispenses with many car riders who would otherwise be needed.

THE COLLEGES—During the past 40 years two mid-western universities have made numerous contributions to railway development, some on their own initiative and others in co-operation with the railways or manufacturers or both. These are Purdue University and the University of Illinois. Beginning in the 1890's Purdue became immersed in a long series of tests relating to problems of locomotive drafting and use of superheated steam in comparison with saturated steam. These latter tests were run on the Purdue locomotive testing plant. From the front-end and smokestack tests was evolved the so-called Master Mechanics' front-end which is still in use as the drafting appliance on a large number of steam locomotives. More recently Purdue has become the seat of a considerable variety of test facilities owned by the Association of American Railroads, including air-brake-hose testing apparatus, drop-testing machines, a brake-shoe testing machine,



Electrical apparatus for measuring stresses and riding conditions in the steam-locomotive counter-balance tests of the Association of American Railroads

an air-brake test rack, and a draft-gear test laboratory.

The Engineering Experiment Station of the University of Illinois is also equipped with a locomotive test plant which has been used in a number of investigations. Illinois is better known, however, for its train-resistance and tonnage-rating tests which were run in 1906 with a dynamometer car on trains in actual service. In addition, this institution is also well known for its work on stresses in railway track.

OTHER SOURCES—Many other important changes and improvements in railway facilities have had their origin in the research of industries not exclusively devoted to the railway market. The list is a long one. It includes the steel, nonferrous metal, chemical, rubber, and wood industries; the manufacturers of electrical equipment and internal-combustion engines, of roller bearings and air-conditioning equipment.

Low-alloy high-strength steel and the strong alloys of aluminum have made possible marked reductions in the weight of railway cars, both freight and passenger. Rubber has been adapted to the insulation of passenger-car bodies against high-frequency vibrations reaching into the sound range. It is also being used as the cushioning medium in passenger-car draft gears. Roller bearings are now widely employed in passenger cars and locomotives. The internal-combustion engine has become a familiar feature of railway motive power. The gas engine in the rail car was followed by the Diesel engine in the articulated motor train. Today, the Diesel-electric locomotive is establishing itself in all classes of service.

NOW AND IN THE FUTURE—During recent years the range of research projects conducted by the railways themselves has increased materially. A long series of laboratory studies has been conducted on locomotive crank pins to find means of improving their fatigue resistance against failure in the wheel fit. These tests are being made for the Mechanical Division, Association of American Railroads, at the research laboratory of the Timken Roller Bearing Company, using fatigue testing machines that were developed for a similar study, completed six years ago, of fatigue properties of full-size passenger-car axles.

Considerations of safety have led to the development of strict limitations on the extent to which fractures in cast-steel freight-car truck side frames and bolsters may be welded. As a means of reducing the need for new castings a thorough study was undertaken of the feasibility of extending these limitations by dynamic fatigue testing of full-size welded castings. This work has led to the removal of restrictions imposed on the welding of these castings and specific regulations for the conduct of the work developed.

One of the problems presented by the steam locomotive of the reciprocating type is the counterbalancing of reciprocating parts. In March, 1944, a report was issued on an elaborate study of this problem which has been conducted on the Chicago and North Western jointly by the Mechanical and Engineering Divisions of the Association of American Railroads. It will undoubtedly influence the designing of future locomotives and the improvement of existing ones so as to provide smoother riding for the locomotive and reduction of track stresses caused by high-speed operation.

In the track field many studies of problems such as butt welding of rail and the design of rail fastenings to improve strength and durability are being conducted, either under the direction of the Engineering Division of the Association or by individual railroads on test installations in main-line track.

Consideration is being given to the redesign of rail sections based on present data relative to failures in the web sections of rail. Another proposal for the improvement of roadbed now being studied extensively is the pressure grouting of roadbed with cement to overcome the effect of water which under certain conditions, accumulates in the sub-grade immediately under the track.

The current problem giving rise to the greatest popular interest is the application of wireless for head-end-to-rear-end communication on trains and for train-to-roadside communication. This is at present under development. While the proposals come from the electronics field, their adaptation to railway conditions without interfering with other fields of radio communication is in itself the subject of prolonged and intensive industrial research.

Intensified interest in the employment of research by the railroads is indicated by the appointment, last March, of Clyde Williams, director of the Battelle Memorial Institute, as technical consultant to advise the Association of American Railroads on research matters relating to technological methods and processes.

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TRACKSIDE SERVICING

With Fuel and Water Increases Locomotive Runs

One of the war-time problems of the railroads is to get the maximum possible monthly mileage from each of the limited number of locomotives available. A measure which has helped to keep locomotives moving is the establishment of facilities for supplying them with fuel, water, and sand, and dumping ashpans for coal-burning engines so that they can be serviced on main-line tracks at intermediate terminals without removing them from trains.

In a paper for the 1944 year book of the Railway Fuel and Traveling Engineers' Association, E. G. Sanders, fuel conservation engineer, Atchison, Topeka & Santa Fe Railway, cites installations which will deliver 42 tons of coal to the locomotive tender in 75 seconds. The coal is delivered through a spout which swings parallel with the track so that the entire coal bunker of the tender can be filled without moving the locomotive. To provide similar fast service to oil-burning locomotives requires oil cranes capable of delivering 1000 to 1200 gallons of oil per minute. Water cranes are now in service that can deliver 7000 gallons per minute.

Mr. Sanders cites the installation of high-speed servicing facilities at two intermediate terminals on a 637-mile run which made it unnecessary to relay locomotives on freight trains at these points. An assignment of 25 locomotives, making 8000 to 9000 miles per month, was thus capable of doing work which would have otherwise required 29 locomotives.

Electronic Aids To Research

Pure and Applied Research Alike Find a Multitude of Uses for the Electronic Tube. From the Laboratory to the Workbench, Electronics is Making Possible New Accuracy in Measurement and Control. A Survey of the Field Indicates Virtually Unlimited Possibilities for Applications of Electronic Tools

By JOHN MARKUS
Associate Editor. *Electronics*

THE ELECTRON, fundamental building block of the universe, is today being put to work by countless scientists and engineers as a research tool to build a better world for the future.

Extensive studies regarding circuit interruption, electrical precipitation, arc welding, and many other fields have removed the limitations to growth of power and industrial activities. These studies have made it possible to meet the ever increasing requirements in the normal growth of the electrical industry and have been especially valuable in the enormous expansions necessary under the present war emergency.

It would take pages to list and describe even briefly every one of the multitudinous applications of electronics in research, development, and quality control laboratories. In almost any laboratory project are found electronic devices for instrumentation or for performing other functions which cannot be accomplished in any other way. Vacuum tubes and special circuits are the tools of the research scientist.

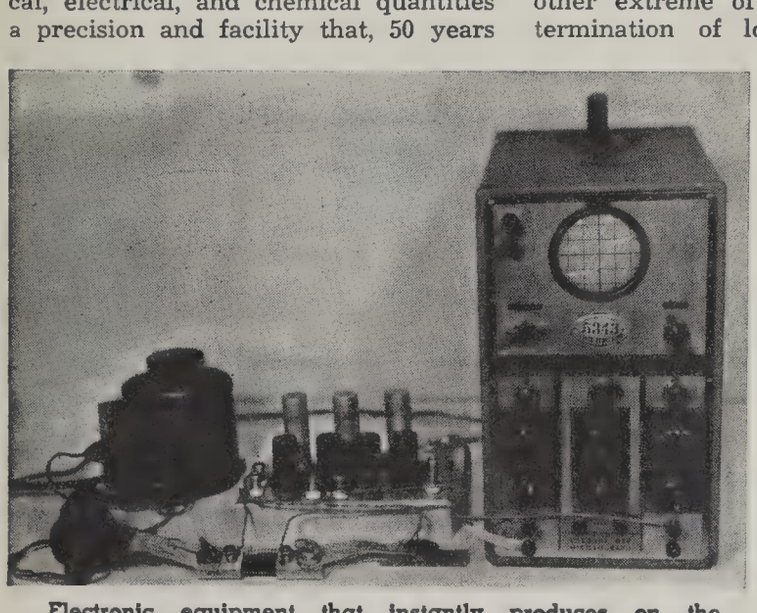
Electronics has brought to the everyday measurement of all kinds of physical, electrical, and chemical quantities a precision and facility that, 50 years ago, were thought possible only in the national physical laboratories or, with the expenditure of much money and labor, in some special project. Today a factory worker will measure the diameter of a piston or check the frequency of a quartz crystal oscillator with a precision of a few parts in a million as readily as the butcher weighs a pound of beef liver. Facility and accuracy are both provided by electronic tubes.

DIMENSIONAL MEASUREMENTS—Lengths and thicknesses are measured today with pointer-indicating gages whose scales can be read several feet away to fractions of a ten-thousandth of an inch. This precision may be achieved with an electromagnetic structure of which the inductance changes with the position of the measuring spindle, or the spindle may move condenser plates. In either case, electronic tubes amplify the resulting change and deliver the result to an indicating instrument. The electron microscope has made possible the measurements of lengths too short for perception by light waves. At the other extreme of length are the determination of longitudinal distances on the earth's surface (primarily a time determination), reaching new exactness by use of radio, and the estimation of stellar distances extended to new fields because of the electronic tube.

The measurement of mass has, perhaps, not drawn out the great variety of electronic devices that have been created for length and time measurements. The mass spectrometer, however, gives trajectories to electrons indicative of their masses and is a powerful tool for the separation of isotopes.

The electronic tube has probably made its greatest contribution in the field of time measurements. The variable-frequency tuned circuit, sustained by the electronic tube, is a powerful measuring tool. Controlled by the piezo-electric voltage of a quartz bar such circuits have yielded time values accurate day after day to better than one part in a million, a precision that the finest astronomical clocks could maintain for only relatively short periods. The cathode-ray oscilloscope records phenomena which may occur in a few millionths of a second. Such an oscilloscope can hunt out the frequency of an unknown voltage and exhibit the contours of its wave shape.

TEMPERATURE—The measurement of temperature, and especially the control of temperature, finds new facility and precision because of the electronic tube. The familiar basic devices—expanding metals and liquids, thermocouples, resistance thermometers—now work through electronic amplifiers so that indicators and recorders can have larger or more sensitive scales, or so



Electronic equipment that instantly produces on the face of the cathode-ray tube the curve that shows the important characteristics of a magnetic sample. This rapid method was developed by Zenith Radio Corporation



These General Electric recording spectrophotometers provide accurate identification or matching of colors for industrial uses or military camouflage. Such work prevents detection of camouflage by infra-red cameras

that the temperature of a space, of a surface, or a kettle of liquid may be maintained with smaller drifting. The measurement of moisture and humidity in rooms, chambers, foods, lumber, soil, and so on, is a related field for which ingenious devices and arrangements utilizing electronic tubes are available.

SPEED—An oscillating tube circuit of which the frequency can be varied at will may excite a flashing light (stroboscope) which illuminates a rotating machine. The frequency of the light which "stops" rotation measures the machine's speed. And since the measuring device has no mechanical contact with the rotating object it can measure the speed of the lowest-powered machine without altering the speed under observation. Obviously this rapidly flashing light may be used for high-speed photography, which has become a powerful measuring aid in the study of high-speed operations. Likewise, when the frequency is held slightly off synchronism the motion of even a high-speed mechanism may be studied closely. Unbalanced vibrations in high-speed machines, down to hundred-thousandths of an inch, may be measured and corrected. The accelerometer, used to determine effective weight during the evolutions of an airplane trial flight, for example, is available solely because of the development of electronic tubes.



Dr. John A. Hipple, Westinghouse physicist, examines the curved glass tube that is the heart of the mass spectrometer, important to research

The sound level meter and associated analyzing equipment which utilize electronic tubes are used to evaluate the effectiveness of devices and materials placed to minimize noise penetrating to spaces which should be quiet.

POWER—The measurement of the power transmitted by a shaft has always been an alluring subject to the research physicist; when the shaft itself can be calibrated as a torque-meter, electronic devices can show readings on a scale. Electric resistance strain gages now take their place beside electromagnetic and mechanical strain gages for measuring shaft distortion as well as the more familiar function of measuring distortion under static stress, and for all of them the electronic-tube amplifier is important.

Electric voltages can be measured with electronic tubes with precision up to frequencies of the order of millions of cycles per second, by the use of negligible power from the circuit measured. The vacuum-tube voltmeter can measure the peak voltage of a fluorescent lamp or of the surge from the starting of an oil-burner mechanism.

Chemical reactions may generate voltages between certain electrodes and, although the accompanying energy is too minute to be detected by other means, the electronic-tube voltmeter or potentiometer serves the purpose. The hydrogen ion concentration (pH) method of determining acidity or alkalinity and the measurement of electrolytic conductivity are of this nature.

Electronic tubes amplify the feeble currents of phototubes measuring light and illumination. Here again there is a notable gain in precision as compared with optical methods. In some instruments, a variety of electronic tubes are combined to produce a measuring device. For example, the recording spectrophotometer is being used by the paint industry to match camouflage colors so that they cannot be detected by the enemy's infra-red cameras. By determining the amount of light or infra-red that is reflected by any paint or other material, it is possible to determine the effect which that material or color will have on the plate of the infra-red camera.

DIFFRACTION—X-ray diffraction methods have been widely adapted to the study of crystal structures since the wavelength of x-radiations is of the same order as the spacing of crystal planes.

The application of x-ray diffraction to problems of research in crystallography and to problems of applied science in chemical analysis and metallurgy, opens a broad field. The scope of the information obtained with this method includes the nature of the crystallographic system, uniqueness or aggregation of crystals, grain size, internal distortion or strain, and the state of atomic chemical combination in a substance.

In metallurgy, x-ray analysis is applied to the study of the constitution of alloys, their intermediate phases, solid phases, and crystalline structure. The effects of cold-working in producing grain distortion, fragmentation of crystal grains, and the introduction of preferred orientation by rolling and drawing are readily determinable.

The determination of a particle size has been extended into the range of submicroscopic grains, as in crystalline colloids. Substances like rubber, carbon-black, paint pigments, cellulose, glasses, and other substances usually considered amorphous have been found to give diffraction rings, and even some liquids produce diffraction halos which yield important information as to their nature and structure. Soils, minerals, dusts, and clays are being analyzed with the new techniques. The study of fibers found in drawn metal wires, silk, cotton, wood, rayon, starches, and stretched rubber is opening new approaches to industrial research. Another new phase of crystal analysis is the investigation of the crystalline and molecular structure of organic com-



Drs. Zworykin (right) and Hillier, of RCA Laboratories, with an experimental model of the electron microanalyzer, latest of the electronic research tools for industrial scientists

pounds, leading to new insight into the mechanism of lubricating films and the behavior of insulating oils and waxes. Research on synthetic resins and synthetic rubber is dependent on x-ray research.

Electron diffraction work on polished metals has given valuable information on the causes of piston and bearing wear. Research on the general problem of adhesion of electro-deposited metals can be expected to result in substantial improvements in plating techniques, while the knowledge gained of surface chemistry, of corrosion, and of the protective oxides on metals and alloys, is directly effective in solving many problems, theoretical as well as intensely practical.

DIFFERING TECHNIQUES — One of the important developments in the technique of electron diffraction was the discovery that electrons impinging at grazing angles on plane polycrystalline specimens would give diffraction rings characteristic of the material in question. Two main types of diffraction analysis are in use today, namely: (1) transmission patterns obtained by passing the electron beam through thin sections of the material, and (2) reflection patterns obtained by impinging the electron beam at grazing angles.

X-ray and electron diffraction techniques differ as a result of the charge characteristic of the electrons and as a result of the wavelengths of the radiation. Electrons are scattered a million times more effectively than x-rays, which fact limits the thickness of the films in the transmission technique. In the case of the reflection technique it is evident that at grazing angles, the first few atomic layers only are effec-

tive in the diffraction. This fact makes the electron diffraction camera extremely useful for the study of surface phenomena.

Electron diffraction analysis is not to be thought of as a substitute for the usual x-ray analysis because of the difficulty of preparation of the specimen for the general case. However, in its special field of surface phenomena, it shows utility.

Among the many problems which have been studied by the electronic diffraction technique are: thin films of inorganic and organic materials; oxide and other corrosion films; polished surfaces; crystal growth; electro-deposited materials; surface catalysis; colloidal state; wear and lubrication; impurities on surface; running in of bearings.

The electron diffraction camera consists of a source of homogeneous high-voltage electrons of 30 to 60 kilovolt energy, a magnetic focusing system, a sample holder and manipulator, and a camera section, all in a vacuum.

One of the interesting applications of the electron diffraction technique has been the study of oxidation and corrosion products of the various metals in different gas atmospheres. This is done by enclosing the specimen in a silver furnace whose temperature is carefully controlled. The samples can be cleaned by treating with hydrogen. The behavior of the metal in various gas atmospheres can then be studied by admitting the gases to the camera for specified time intervals at various pressures. At the conclusion of the experiment, the camera is evacuated and the diffraction picture taken at the temperature in question.

MAGNETIC CHARACTERISTICS — The characteristics of the magnetic material used in transformers and chokes are not easily measurable, and introduce a factor of uncertainty in the design and production of electrical equipment. A specified grade of lamination material may be essential for proper operation, but the various grades look very much alike, and electrical checks are often quite difficult.

Sometimes a deterioration in the characteristics of some complex circuit defies explanation until the change is traced to a change in characteristics of magnetic materials.

Apparatus for rapid and easy testing of magnetic materials is extremely useful in such cases. But to obtain such data as permeability, saturation, coercive force, and hysteresis loss of magnetic alloys, special equipment which is not easily available has been necessary.

The oscillographic equipment makes it possible to obtain these data with great rapidity. Comparison checks of a number of samples can be made within a few seconds. Initial and reversible permeability characteristics, or increase of loss with flux density, can be directly observed on the screen of a cathode-ray tube.

A little washer punched from a single lamination is all that is needed. Using a special four-tube amplifier and test jig with an ordinary cathode-ray oscilloscope, the electronic apparatus instantly provides a curve giving the desired information.

RESISTANCE MEASUREMENTS — Wire resistance strain gages are primary elements for measuring small linear changes of dimension of the surfaces to which they are attached. The surface strain causes a proportional percentage change of electrical resistance of the gage, which is measured with a suitable instrument. Most applications of these gages depend on the use of electronic instruments to get the necessary high sensitivity and measuring speed. The measurement of mechanical forces, weight, fluid pressures, and small motions are applications of strain gages and their associated electronic circuits to industrial problems.

Practically all commercial gages are rectangular grids of resistance wire about 0.001 inch in diameter, supported and held in place by a film of elastic cement. This may be strengthened by the further use of a paper backing. This structure of wire and cement is in turn cemented to the surface on which strain is to be measured.

When a conductor is placed either in tensile or compressive stress, its electrical resistance changes. With electronic circuits, this change in resistance is readily converted to an indication of the stress in the structural number being examined.

MASS SPECTROMETER — Production of high-octane gasoline, so important to war planes, involves precise critical processes requiring laboratory accuracy on a huge scale. Previously, chemical tests in an oil refinery have been laborious and have required hours to complete, but today the electronic mass spectrometer thoroughly checks operations in a matter of minutes—and requires only one or two technicians.

This instrument determines both qualitatively and quantitatively the constituents of a gas, using only a thimbleful of the gas at a time—and ionizes it by impact of electrons from a hot filament in an evacuated tube. The stream of charged molecules is drawn along the tube into a strong magnetic field, where it is bent into an arc-shaped path. The heavier the ion, the larger the radius of curvature of its path. As a result, different molecules emerge from the field at various locations—but all of the same kind leave at one particular spot. Differently charged molecules are collected successively at an exit slit into a current that can be amplified and measured. In this way, constituents of any gas can be determined as to kind and proportion.

The value of the spectrometer as an analytical tool in the analysis of gasoline, synthetic rubber, and plastics well justifies its development. Already in evidence are other promising fields of application. Among these are leakage testing, metallurgical analyses, and analysis of the purity of controlled furnace gases. It is also useful in automatic controls of processes where it may be important to measure the relative quantity of a desired constituent or to detect presence of an undesirable element.

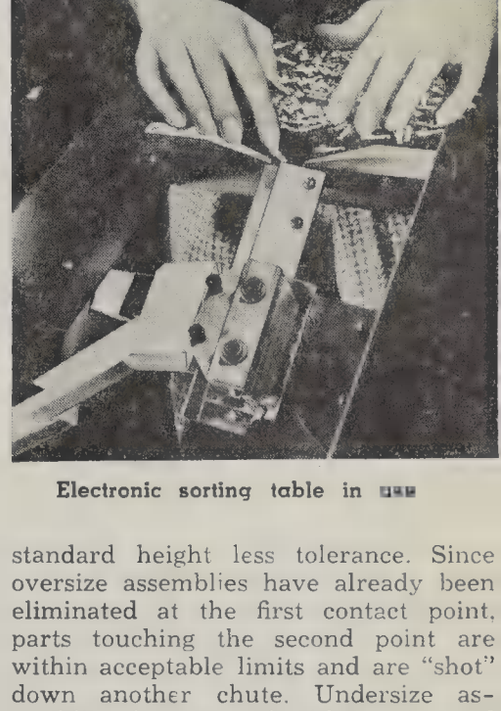
CONTACT ASSEMBLIES
Sorted Electronically into Three Groups

MUCH greater speed in the sorting and inspection of tiny contact assemblies produced at General Electric's Schenectady Works has been made possible through the development of an electronic sorting table which routes the assemblies into three different channels depending on whether they are too high, too low, or within the tolerances.

Each contact assembly was previously checked with a needle micrometer to determine whether it was oversize, undersize, or within the tolerances, and then sorted accordingly by hand. With the specially designed sorting table, each assembly is fed onto a 45-degree slide. About halfway down the slide, the assembly comes to a contact point located at a pre-set height.

If the assembly touches the point, it is oversize, and the contact made closes the grid circuit of a vacuum tube, which in turn energizes an electromagnetic relay. A solenoid is next energized, sending the assembly down a chute into a container for oversize parts.

A short distance beyond the first point, a second contact point is set at standard height less tolerance. Since oversize assemblies have already been eliminated at the first contact point, parts touching the second point are within acceptable limits and are "shot" down another chute. Undersize assemblies do not touch either point and slide undisturbed to a third tray, thus completing the automatic sorting operation at high speed.



Electronic sorting table in use

Research Gave Mankind Wings

From the Very Beginning, Research has been the Basic Element in Aviation Progress. The Wright Brothers Built a Wind Tunnel Long Before They Built A Flying Machine. From Then on, Research by Industry, Government, and The Universities Has Brought Flying to Its Present Astonishing Triumphs

It is a remarkable fact that, the younger a branch of engineering, the more it owes to organized research and the more thorough is its grasp of underlying scientific principles. Thus naval architecture, which presumably dates back to Noah, has advanced through the ages mainly by experience, and with much of its knowledge based on tradition.

Aviation, on the other hand, dating back only a little more than 40 years, owes far more to scientific research. It has advanced more rapidly; it is more richly provided with laboratories, and it already has gained sounder and more comprehensive scientific knowledge. In fact, the tradition of research in aviation dates back to the Wright brothers themselves.

It is sometimes thought that the Wrights were inventors of genius who owed their success to inspiration and not to scientific training. On the contrary, the two brothers were scientists of the very highest type. While they owed much to inventive genius, they nevertheless undertook long and systematic researches in a home-made wind tunnel before they even attempted to build their first airplane.

For many years Orville Wright used to show personal friends a small red vest-pocket book which contained the sole record of early experiments. Only in 1939 were these records given to the world in the 27th Wilbur Wright Memorial Lecture delivered by Dr. G. W. Lewis before the Royal Aeronautical Society. In this lecture, Dr. Lewis gave ample evidence of the research skill and accuracy which the Wright Brothers had achieved. The tradition has remained, with scientific and industrial research in aeronautics undertaken by every civilized or merely technologically-trained country in the world.

The United States has a way of originating inventions, of neglecting them, and, later on, of surpassing the world in the same field. So, in aviation, the Government paid but little heed to the new science. Only in 1915 was the National Advisory Committee for Aeronautics established, and even then with a munificent grant of $5000 to pursue its researches. Of course, today America is in the lead both in research equipment and personnel, but it is doubtful whether we were leading in those crucial years when the dictators were arming for the conquest of the world.

RESEARCH IN EUROPE—In those dangerous years, Mussolini had built Guidonia, a whole city devoted to scientific research in aviation. In Germany, the Deutsche Versuchsanstalt für Luftfahrt, located at Adlershof near Berlin, had vast laboratories and workshops, as well as large numbers of well-trained men. The Russians had developed the huge Central Aero-and-Hydrodynamic Institute in Moscow. The British, while sound, had not kept their early leading position, and in France an early spirit of bold investigation had yielded to apathy and decay.

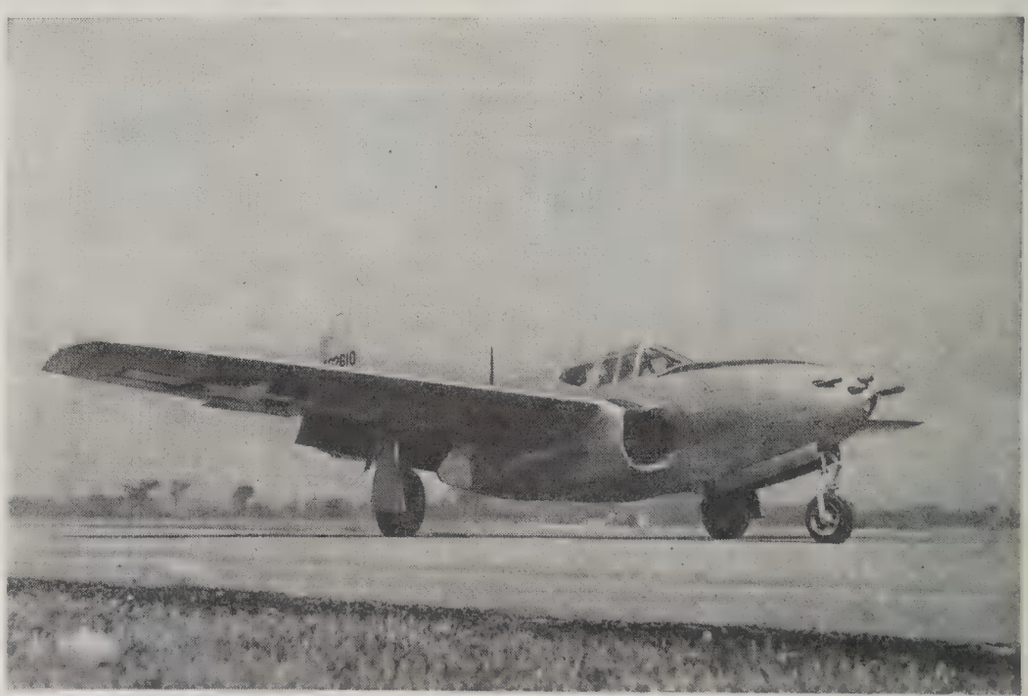
The Japanese, who excel as copyists, it is true, but can also do good research along conventional lines, had built up the quite respectable Tokyo Institute of Aeronautical Research. Particularly in Germany, the efforts of the government scientists were supported by industrial research and experiment on a wide scale by such companies as Junkers, Dornier, Heinkel, and others. Charles Lindbergh tried to do his country a service when he reported how powerful and advanced was German aviation.

The early days of the European war and even the early days of our own entry into the war certainly did not find us leaders either in aeronautical research or in excellency of airplane equipment, while quantitatively we were far behind.

It was our good fortune that Great Britain put up so courageous a fight and that two oceans separated the United States from its potential enemies. We were thus given time to bring our research facilities up to the highest level and to advance our military and naval aircraft to their present excellency.

Today, perhaps the most remarkable thing about aviation research in the United States is the co-operation which exists between governmental laboratories, the universities, and the experimental establishments (rather than laboratories) of the manufacturers of airplanes and airplane engines.

In the pure science of aerodynamics, the Germans led, up to a few years ago, but today they are rapidly going down hill. Now, thanks in part to the refugees which Germany has so benevo-



A fine product of war-time research—the Bell Airacomet jet-propelled plane

lently driven to our shores, we are fast overhauling them in the physical sciences and in applied mathematics. In the application of science and in industrial research we are already far ahead of the Germans.

In aviation we in the United States owe our superior position to the fact that we have known better than the Germans how to tie in our federal laboratories with the industrial research of our manufacturers and with the universities. It will not be out of place to give a brief picture of these diverse but co-operating elements.

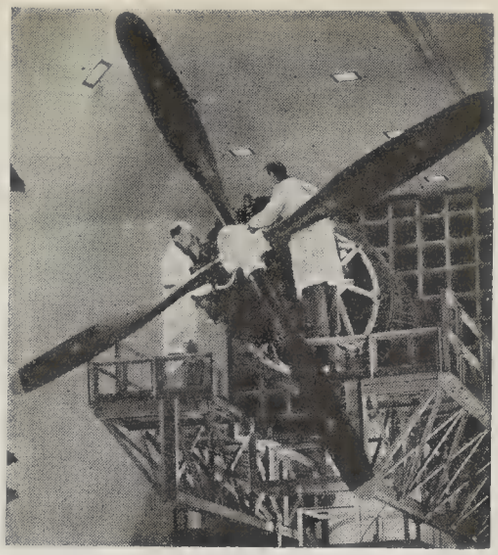
To begin with, this country has the National Advisory Committee for Aeronautics. This, from its modest beginning in 1915, has now grown to a vast institution with its long-established Langley Field laboratory in Virginia, now almost matched by the Ames Laboratory in California, and supplemented by the splendid aircraft engine laboratory put into operation just a few years ago in Cleveland. The NACA, as it is generally known, is directed by a group of men who serve without compensation and who represent the Army, the Navy, the Civil Aeronautics Administration, and other governmental bodies, with perhaps one or two citizens of high distinction in aviation.

Under this governing committee functions the Director of Aeronautical Research, Dr. G. W. Lewis, who has established, perhaps, the Washington record for longevity in a prominent government position and perhaps an equal record for freedom from public criticism. Then there come a number of sub-committees which include members representing the industry and the universities. Research problems are frequently suggested by engineers from industry at the annual NACA Conferences held at Langley Field. Sometimes they are presented by the industry's representatives acting on the sub-committees. When research is initiated by the NACA itself or by members of its scientific staff, the subjects of investigation have to be approved by the sub-committees. There exists the most friendly relationship between NACA and the industry.

DEMOCRATIC RESEARCH—In a large measure, this is due to the fact that the NACA has known how to draw the line between the solution of fundamental problems and the *ad hoc* research which develops particular airplanes, engines, instruments, and accessories, and which is properly the realm of industry. The whole system of interaction between government laboratory and industry is a remarkable manifestation of the democratic process.

What results has this democratic scheme produced at Langley Field? It has yielded, first of all, the most systematic and correlated knowledge of airfoils available anywhere in the world. The NACA family of airfoils is quoted, studied, and used in every country and, in all probability, Hitler's proudest aircraft are equipped with NACA airfoils in their original or slightly modified form.

The NACA laminar wing maintains a laminar or smooth flow over the greater part of its surface, and, when operating at its best efficiency, cuts down the drag of the airfoil tremendously. Since, in the modern airplane, the profile drag of the wing constitutes a large proportion of the whole drag of the airplane, the laminar wing has meant much to the efficiency and performance of our fastest military aircraft. As the speed of the airplane increases, the local speed of air flow at certain points on the surface of the wing approaches the speed of sound, with the compressibility burble and shock waves as the result, and this compressibility burble at one time threatened to put an end to further advances in speed. Again, the NACA researches have gone far to bare the causes and remove the vexations of the shock waves.



Preparing a 16-foot, 8-inch, diameter propeller for testing in a Curtiss-Wright propeller-research test cell

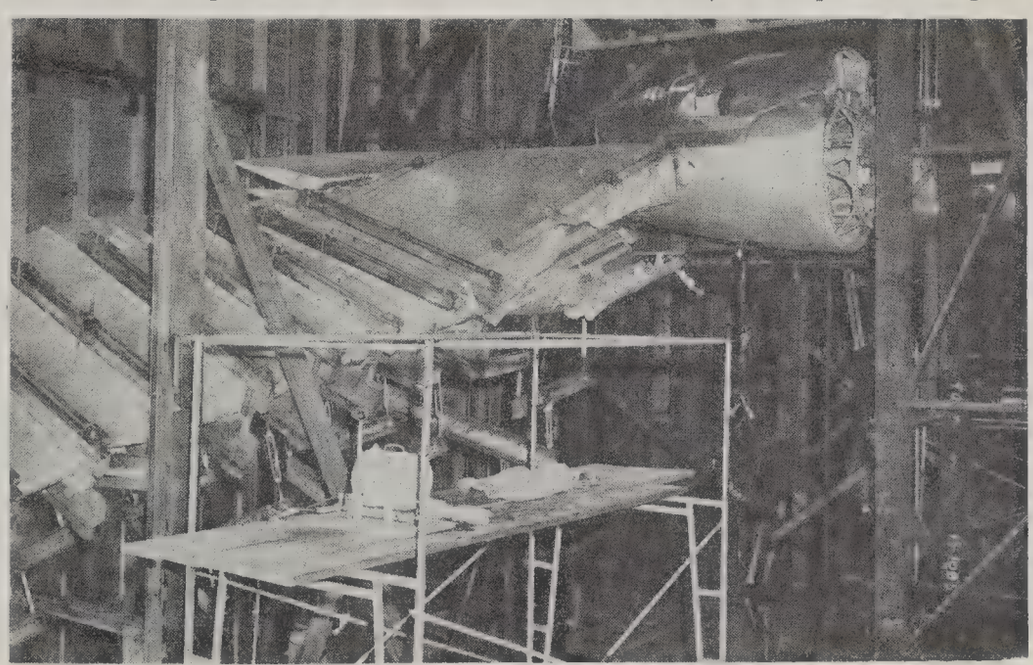
It is a well-known fact that America leads the world in the design of air-cooled engines. Such engines could never be used with the efficiency now available were it not for the NACA streamlined cowl which is seen in every picture of war-time aviation. To the NACA, America also owes a number of advances in experimental technique which have been copied or improved upon the world over. Thus, Langley Field was the first to construct the Compressed Air Tunnel in which the air, compressed to a pressure of 20 atmospheres, gives test conditions whereby small models can simulate the behavior of full-scale airplanes. To the NACA also, the United States owes the construction of the world's largest towing basin, and the knowledge derived in the towing basin has been an important factor in the development of our transatlantic Clippers. In addition, the NACA developed the high-speed tunnel in which the compressibility problems mentioned can be thoroughly investigated. America is also indebted to it for the first tunnels large enough to make possible the test of engine and propeller combinations, and the first tunnel (60 feet in span) in which it was possible to test a full-scale airplane.

Our universities, too, have fulfilled an important function in aviation. They have produced, in addition, such young leaders of the industry as Wellwood Beall, responsible for the Superfortress, who is only 37. It can be said that the American aviation industry, and American industry in general, as it has supported the aviation industry, has lived up fully to the lead of the NACA, and in fertility of ideas and in vigor of invention has surpassed the governmental institution.

INDUSTRY'S CONTRIBUTIONS—So much has been done by industrial research in aviation in the last 20 years and so much more under the recent pressure of the war effort, that it is difficult to select outstanding achievements.

The following is only a rough attempt at such selection. Long-distance flying and bombing in bad weather are possible only because the military pilot can pass on a large share of his task to the robot pilot. Elmer A. Sperry gave the world the Sperry automatic pilot based on a refined application of the gyroscope. It is a remarkable fact that the Sperry Company has persevered in this development for nearly 30 years.

Flying in the substratosphere would be impossible without the supercharging of the engine for the thin air of high altitudes. When America needed a supercharger, it found Dr. Sanford Moss, a compressor designer



Testing a Boeing airplane wing to destruction

who, with the full backing of the General Electric Company, gave it the turbo-supercharger which is making history every day.

Charles L. Lawrance and, subsequently, the Wright Aeronautical Corporation contributed the air-cooled engine, which was ultimately developed into a prime mover of over 2000 horsepower.

The principles of radar, first announced by two American naval scientists in 1922, were developed in England and saved her in the Battle of Britain because radio locators could find the Luftwaffe even at night. But radar received its finest development in the industrial laboratories of the United States. This branch of electronics, contributing vastly to the war, will also be of great help to peace-time aviation.

American industry has given us the materials and the "know-how" to enable the turbo-jet engine, coming from England, to surpass the fondest hopes of its original inventor, Captain Frank Whittle.

American ingenuity has produced the marvellous "thinking," automatically-computing gunsight which enables one of our pilots to shoot down his enemy when their relative speeds are nearly 1000 miles an hour.

From this brief survey of industrial aviation research, a few tentative conclusions may be drawn.

First of all, it is American industrial research which is one of the primary causes of American aerial supremacy. Since such research is the outcome of years of steady growth, and since laboratories and technicians cannot be improvised, it would be the worst kind of folly for the United States to discontinue aviation research after the end of the war. Let Congress cut, if it will, the mass production of aircraft. Not for one moment, however, can America afford to discontinue its efforts in aviation research.

Another statement which few will care to dispute is that the aviation research which for so long has been devoted to military ends, will indirectly cause peace-time aviation to flourish as a small compensation for the agonies of war. The automatic pilot will carry transports to the uttermost regions of the earth. Applications of radar will enable planes to land in the thickest fog. Supercharged engines and supercharged cabins will carry passengers at unbelievable heights in great comfort and at speeds which are impossible at lower altitudes.

AVIATION'S DEBT PAID—In the early day of aviation, the new-born science drew on the skill of men from other professions and built its equipment with the aid of other industries. Now it has more than repaid this debt.

Other industries have learned a great many things from industrial research in aviation for application in their own needs. For example, the turbo-jet engine will undoubtedly pave the way to advances in the gas turbine for general use. Because, in building the turbo-jet engine technicians learned how to design nozzles and select materials to withstand severe combinations of temperature and pressure, gas turbines can be expected in locomotives, in ships and, later, even in motor cars. Because radar has rendered so many services in aviation, the mariner will find it equally useful at sea.

Because supercharging has introduced the most difficult problems in heat exchange, the entire air-conditioning, heating, and ventilating industries will benefit. Because airplane builders had to face the highest decibel levels of powerful engines and fast-revolving propellers, sound-proofing will advance in many fields of industry and comfortization.

Because automatic pilots, airplane compasses, distance fuel gages have made use of electronics in its most refined form, and because remote indication and control have been indispensable in aviation, there will follow progress in many fields of industrial instrumentation and control.

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DEATING COMPRESSIBILITY

By Means of Two Simple Hinged Surfaces

WHEN an airplane approaches the speed of sound, as it may in a power dive, strange things happen to the airflow past the wing. The air, which flowed smoothly around the wing at lower speeds, now suffers "compressibility" effects. Shock waves are produced on either the lower or the upper surface of the wing, or on both. Pressure on the lower surface is likely to be converted into suction, while suction on the upper surface may become pressure. The efficiency of the wing is destroyed.

But that is not so serious as the fact that compressibility in the power dive produces violent buffeting effects on the tail, the pilot loses control, has tremendous difficulty in pulling out of the dive, and generally finds life unpleasant for the moment.

Now the engineers of Lockheed Aircraft Corporation, headed by their aerodynamicist, C. L. Johnson, appear to have found a remedy, which has worked splendidly on the Lockheed P-38 or Lightning and is being successfully tried out on other planes. Military secrecy still forbids detailed discussion of the device itself or of its theory, but the photograph shows how simple it is. Two simple hinged surfaces constitute the entire device. When they are outside the wing they break the shackles of compressibility; when retracted, they leave the airplane all its usual aerodynamic efficiency. After a power dive of 35,000 feet the Lockheed Lightning equipped with this device can pull out safely within 3000 to 5000 feet.



Compressibility shackle-breaker

ATTITUDE INDICATOR

Aids Pilot in Acrobatic Maneuvers

BY MEANS of a gyro equipped attitude indicator, the airplane pilot can now be provided with a visual indication of the position of his plane with reference to the earth, through all the possible attitudes into which an airplane can be maneuvered.



Airplane attitude indicator unit

In the past it has been impracticable to perform all aerobatic or acrobatic maneuvers without visual reference to the earth's surface. With the new Sperry Attitude Gyro it is possible to carry out such maneuvers even when the earth cannot be seen. The instruments thus constitutes an advance in training methods, and is also likely to be of help to combat pilots in a tight corner.

As in other gyro instruments, a gyroscope is the heart of the Attitude Indicator. It is electrically revolved around a vertical axis, and has the familiar gyroscopic properties of rigidity and precession, in order to provide an absolutely fixed vertical pattern around which the plane may be maneuvered.

The new feature is made possible by a novel method of suspension. The reference pattern is marked on the surface of the stabilized sphere with luminescent paint and is visible to the pilot through a marked opening in the front of the instrument case. The indicating sphere is divided into hemis-

pheres by painting the upper half white luminescent and the lower half black.

The only operating knob or adjustment required by the pilot is that for the "target"—a small circle which adjusts up and down to compensate for change in trim of the airplane in level flight.

AIR TRAVEL

Growth Predicted by Result of Recent Study

A REPORT by B. A. McDonald and J. L. Drew, which is a thorough and thoughtful study of what awaits aviation in the post-war years, has been issued by Curtiss-Wright. The report is based on assumptions of complete allied victory, a steadily growing income, growth of air transport based on economic rather than political considerations, regulation by Congress and The Civil Aeronautics Board following precedent, and on a continued, vigorous policy of air-traffic promotion.

Improvements in service may be expected, due in part to war-time developments applied to peace-time air transport. The number of accidents should become so low that fear of air travel will be entirely eliminated as a deterrent. Since fear has, in the past, kept more passengers away from air travel than any other cause, or causes combined, this advance in safety is of the utmost importance. Flight cancellations should be virtually negligible and almost 100 percent schedule performance may be expected.

Radar developments will help, as will also the blind landing systems which need only be installed at our great airports to be fully effective.

The comfort of air travel will increase greatly. Cabin pressurization; better lighting; excellent vision; complete soundproofing; stable flight, thanks to the automatic pilot; all are combining to make air travel more comfortable.

As a result of these favorable influences, the Curtiss-Wright report predicts an enormous increase in air travel, with number of passengers seven times that of 1940, five years after the war's end; with 700 million passenger miles a year as against 104 millions in the earlier period. A similarly rapid growth is expected in air express, with an estimate of 87 million ton-miles annually, compared with 10 million in 1940.

JATO

Rocket Units Being Tested For Assisted Take-Offs

IT IS not accidental that both the Navy and the AAF are experimenting with jet-assisted take-off—the readiest way of getting an over-loaded plane into the air.

The Navy has applied this principle to the Chance Vought F4U-I Corsair fighter. JATO, as these assisted jet take-offs are known in the Navy, reduce the normal take-off run from 33 to 60 percent of normal, or else they permit a greatly increased load to be carried. These devices are particularly useful in the restricted areas of carrier decks.



Rockets give added push

They resemble bombs, except that they are fixed to the under side of the fuselage rather than under the wing or enclosed in bays.

The jet units are really rockets (not jet engines) because they contain solid propellant which includes oxygen and do not take in air from the outside. They are ignited by electrically controlled spark plugs.

Air Technical Service Command experiments with such rockets have been going on at Wright Field for four years, with considerable technical success. It is not equally certain that they will be as helpful tactically. If runways are built so short that rockets are required for take-off, then the same runways will be short enough to cause many accidents on landing.

The rockets carry both fuel and oxygen, with the products of combustion escaping to the rear through a suitably shaped nozzle. There were two major problems to overcome—suitable fuels and oxidizers, and a nozzle which would stand the terrific heat of the ignited gas. Both problems have been solved, although better combinations of fuels and oxidizers are still being sought.

The Air Technical Service Command rightly warns us that rockets may be helpful in assisted take-off but have yet to show utility in long-range flight. The Germans are reported to have placed such take-off units in tactical use, possibly because their propellers, designed for high altitude, do not give sufficient thrust for good take-off at sea level.

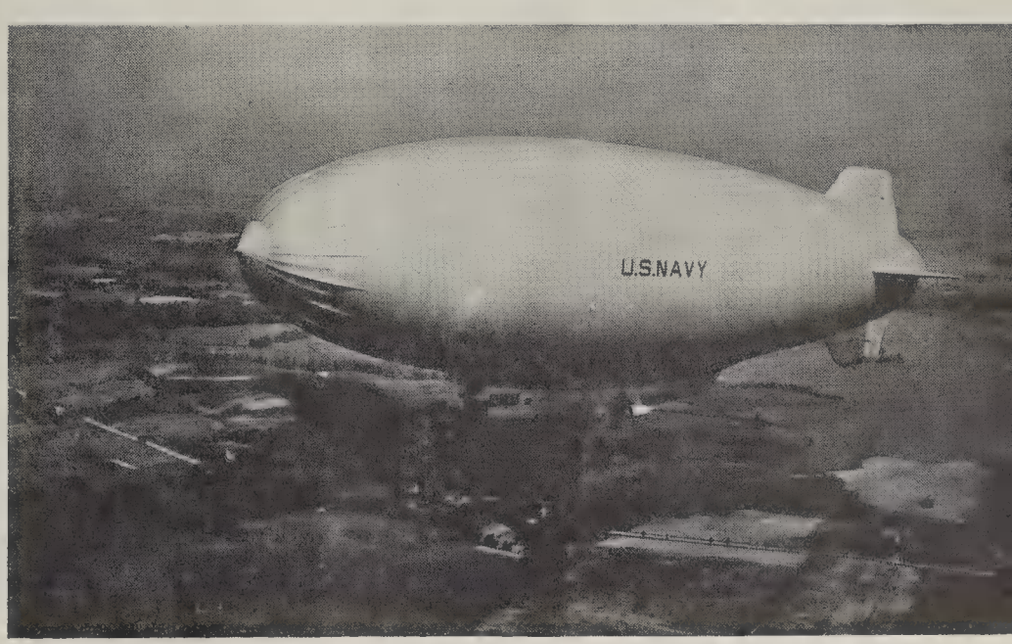
REVERSIBLE PROPELLERS

Make New Navy Blimp More Maneuverable

BLIMPS have given a good account of themselves in the present war, and have proved invaluable in anti-submarine patrol. As compared with the airplane in such duty, the blimps have long endurance, can stay aloft for several days, and are able to hover over one spot; an airplane is obliged to fly relatively fast if it is to stay in the air, and has an endurance of only a few hours. Also, the blimps, when equipped with appropriate propellers, have a great deal of maneuverability. Such propellers are the Curtiss electric propellers with fully reversible pitch which have been installed on the Goodyear M-I, the largest airship of this type owned by the Navy, shown in the photograph below.

The M-I is equipped with a mooring ring at the bow and a long lower structure with navigation and observation quarters at its front end. Nacelles on either side of the hull are braced by two powerful girders and contain 500-horsepower engines. With the use of the reversible propellers the blimp can be brought to a stop in the air and with the blades of one propeller pulling forward and the blades of the other pulling backwards, the M-I can turn in the air as if on a pivot.

It is also possible to make a running start into the air, with wheels on the ground. The blimp is then making use of the dynamic lift of the hull like the dynamic lift of an airplane wing. In general, ground handling qualities of blimps will be greatly improved by the reversible pitch mechanism, which has already proved very useful in maneuvering flying boats on the surface of the water.



Maneuverability of the M-1 is increased by reversible propellers

Plastics—Products Of Research

No Other Industry Has Profited So Greatly by Laboratory Research Than Has the One Built on the Original Work Done 75 Years Ago by Hyatt. A View of Accomplishments of Very Recent Years Serves as a Basis for Evaluation of Progress Yet to Come. Only the Surface has been Scratched

IN THE 75 years that have passed since John Wesley Hyatt founded the plastics industry by evolving the cellulose nitrate formulation known as Celluloid, new plastics materials have poured forth from research laboratories throughout the country.

In the past few years, the spur of war demands has abetted and perhaps forced the development of many new techniques and new plastics materials. And it has had a further effect. The exigencies of meeting rigid demands and specifications of the many Government offices and agencies, have brought about improvements in materials and methods of manufacture which will be of permanent benefit to the plastics industry long after peace is restored.

SHATTER-RESISTANT GLAZING—Characteristic of the activities that have engaged the attention and efforts of the plastics industry during the war years is the development of shatter-resistant plastic glazing. The history behind this Lucite-Butacite glazing, which is capable of resisting shock impacts such as the effects of penetration by machine-gun and cannon fire, or gunfire concussion, presents many interesting lights on the varied experience, the research, and the testing that must be called into play in the development of new plastics applications.

The strategy of modern aerial warfare involves the operation of aircraft at high altitudes, often in excess of 35,000 feet, where atmospheric pressure and temperatures are low. Hence pressurized airplane cabins were evolved whereby the atmospheric pressure inside the plane, at 40,000 feet for example, can be maintained at the equivalent of the atmospheric pressure existing at 12,000 feet, the highest altitude at which humans can live efficiently without accessory oxygen.

Pressurized cabins have another advantage. Heavy clothing, heated suits, and oxygen masks—burdensome when worn over long periods of time, as on bomber missions deep into enemy territory—can be discarded in planes equipped with pressurized cabins except, of course, during the period of actual bombing when an enemy shell might pierce the fuselage.

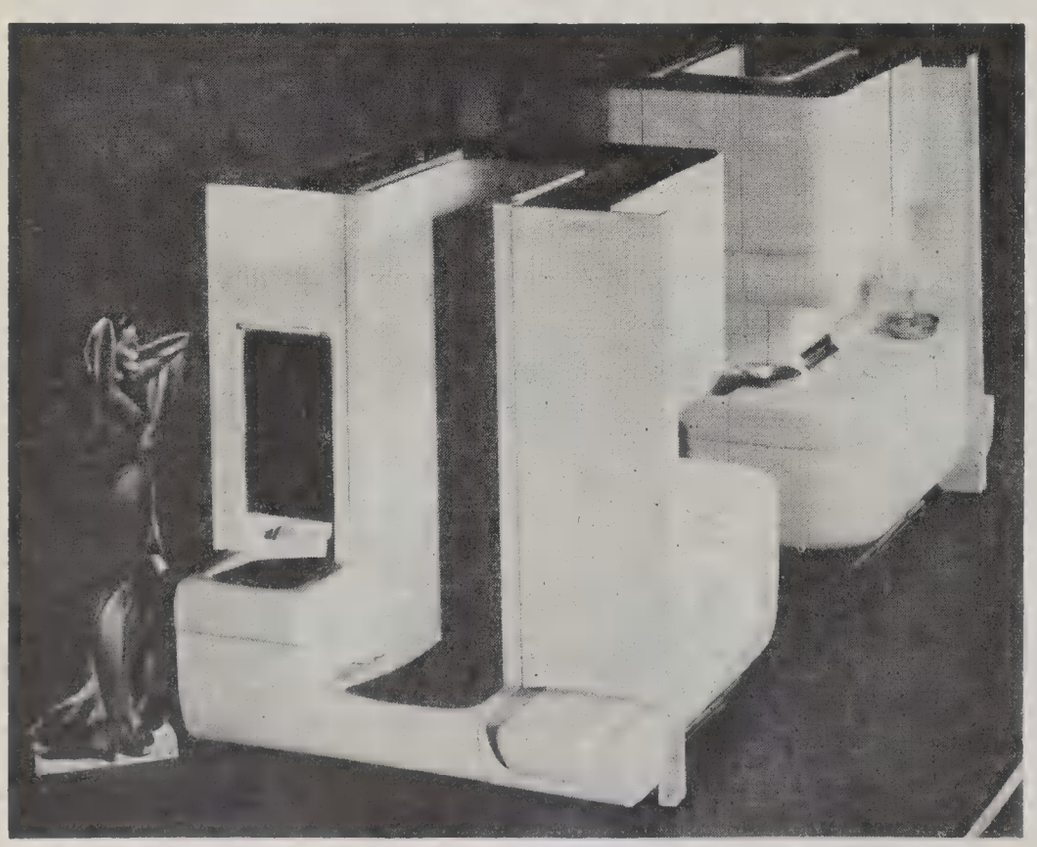


Courtesy Canadian Industries, Ltd.
Polyethylene insulation is used in various high-frequency cable types

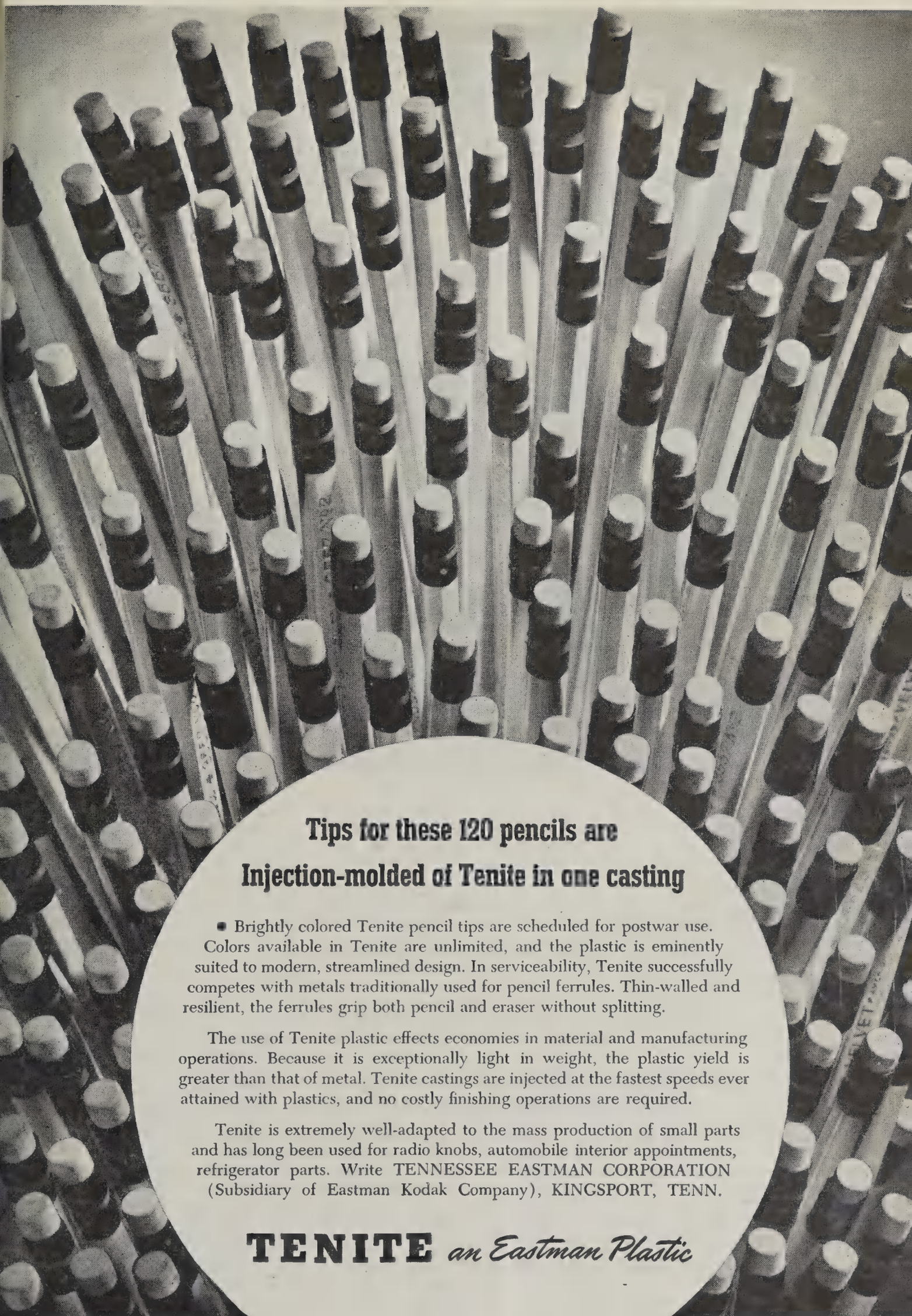
The problem then arose of preventing the escape of air from within the cabin when machine-gun fire pierced holes in the transparent plastic domes of pressurized cabins.

In the absence of a glazing that would resist enemy gunfire, a search was begun for a transparent plastic material which would, when penetrated by a bullet or shell, be self-sealing. Since no one plastic possesses transparency, the ability to be easily shaped, and the simultaneously contradictory property of rigidity with maximum flexibilty under shock impact to prevent shattering, the next step was to combine two materials which, when laminated together, might retain the desired qualities of each of its individual components.

Methyl-methacrylate was selected as one of the materials because of its rigidity, hardness, and weather resistance; and polyvinyl butyral resin was selected as the second component because of its tough, elastic, impact-resistant qualities. The experience and skill gained in the production of laminated safety glass was then applied to this new material, with sheets of methyl methacrylate placed on either side of a polyvinyl butyral sheet. Since polyvinyl butyral will not adhere to methyl-methacrylate, it was necessary to develop a special adhesive which would produce a strong bond between the two plastics, and several hundred



For the home of the future, bathroom and kitchen sections may be assembled from plastics units. Many different arrangements of the parts will be possible



Tips for these 120 pencils are Injection-molded of Tenite in one casting

• Brightly colored Tenite pencil tips are scheduled for postwar use. Colors available in Tenite are unlimited, and the plastic is eminently suited to modern, streamlined design. In serviceability, Tenite successfully competes with metals traditionally used for pencil ferrules. Thin-walled and resilient, the ferrules grip both pencil and eraser without splitting.

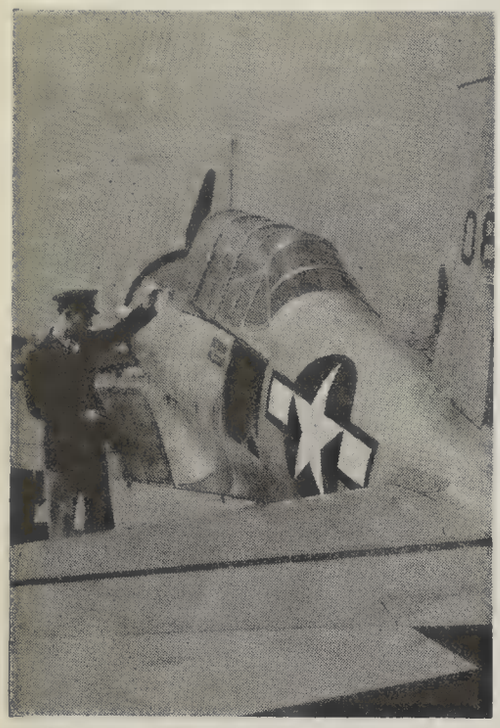
The use of Tenite plastic effects economies in material and manufacturing operations. Because it is exceptionally light in weight, the plastic yield is greater than that of metal. Tenite castings are injected at the fastest speeds ever attained with plastics, and no costly finishing operations are required.

Tenite is extremely well-adapted to the mass production of small parts and has long been used for radio knobs, automobile interior appointments, refrigerator parts. Write TENNESSEE EASTMAN CORPORATION (Subsidiary of Eastman Kodak Company), KINGSPORT, TENN.

TENITE *an Eastman Plastic*

adhesives were tried before a satisfactory type was obtained.

Results fully justified the painstaking research involved in the successful development of this shatter-resistant plastic glazing. Tests on a ⅜-inch thick laminated semi-cylinder of this material showed no rupturing and only very small holes after being penetrated with a .50-caliber bullet under conditions where the pressure differential was 7.5 pounds per square inch and the temperature was —40 degrees, Fahrenheit. Further, these small holes can be patched by a crew member while the plane is in flight.



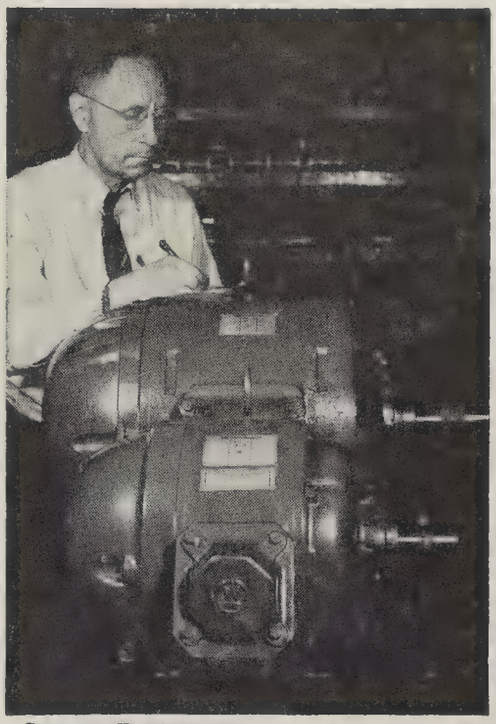
The first BT-15 airplane to employ "sandwich" type of glass-plastics construction for such structural parts as the rear section of the fuselage, tail cone, and side panels

STRUCTURAL AIRCRAFT PARTS—Probably the most noteworthy application of plastics to be made public during the year 1944 was the construction by the Army Air Forces Materiel Command at Wright Field of a Fiberglas laminated fuselage, tail cone, and side panels for a BT-15 airplane. This fuselage was the first primary structure in an airplane to be made successfully of laminated plastic. In the past, various plastic laminates had been used in the construction of non-structural airplane parts—fairings, fillets, doors, escape hatches—not subject to severe stresses, but none had exhibited the physical properties necessary for primary structures.

The success with which this experimental fuselage withstood the most stringent laboratory and field tests suggests a wide field of application in the future in the automotive, maritime, and building fields, as well as aeronautics.

Basically, the test fuselage for the BT-15 consists of glass cloth impregnated with resin to which a certain amount of glass fiber flock has been added to give increased strength. Sandwich-type construction is used, incorporating a balsa-wood core between an inner and outer skin of the laminate. No pressure is required for curing the newly developed resin used for this application. After laying up, the fuselage need only be subjected to a temperature of 220 degrees, Fahrenheit, for a period of three hours, after which it is ready for the trimming and finishing operations.

This laminated structural airplane part represents a synthesis of the results obtained from many years of research and test work in numerous fields —work that is still going on to perfect the material and the method of fabrication and make it practicable for large-scale factory production. On the one hand there is the long-range development conducted by Owens-Corning Fiberglas Corporation in the production of different types of glass cloth; on the other the research activities of seven resin manufacturers—Pittsburgh Plate Glass Company (Columbia Chemical Division), American Cyanamid Company, Libbey-Owens-Ford Glass Company (Plaskon Division), Dow Chemical Company, Monsanto Chemical Company, Bakelite Corporation, and Marco Chemicals, Inc.



Courtesy Westinghouse

Use of silicone insulation accounts for the fact that the 10-horsepower motor in the foreground is half the size of the other, of the same rating, which has conventional insulation

PLASTICS IN THE HOME — Just as the use of glass-reinforced low-pressure plastics for aircraft structural parts is well beyond the pure laboratory phase, so post-war applications of these same materials are now beyond the planning period. Perhaps the most interesting and promising of the proposed uses are to be found in models for space-saving, structure-supporting, prefabricated kitchen and bathroom units, which have been projected by Virginia-Lincoln Corporation.

These bathroom-kitchen designs take advantage of the ideal properties of glass laminates for individual units that are integral with standardized interchangeable wall sections. Many of the excellent features of these models would be impracticable to manufacture if the costly dies of high-pressure molded plastics were necessary, and on-the-spot assembly would be complicated if the units were made of light-weight metals.

The two-sided assemblies, which comprise a bathroom and kitchen, complete with full storage facilities, are intended in their most compact form to occupy a space only seven feet square yet are capable, because of airplane-type cantilever beams, of supporting the entire structure of the house. The strength of the main supports can be attributed to the use of straight-line, continuous glass fibers that are coated with a resin admixed with short lengths of finely divided glass-fiber flock.

The properties of this material make the glass fiber laminate ideally suited for the forming of refrigerators and plumbing units, and for strong, light, highly stain- and mar-resistant furniture for existing bathrooms and kitchens. Chairs and tables for terraces, even park benches, would possess improved weather resistance if formed from this material. Luggage is another market that offers interesting possibilities.

ENTER SILICONES—That returns already are being realized from the intensified war-time research is evidenced by the first commercial production of "silicones." Available as fluids, greases, resins, and lubricants, these materials, which are produced by Dow Corning Corporation and General Electric Company, bridge the gap between conventional organic insulating materials, which are limited with respect to heat stability, and ceramic-type materials, which have no such limitation.

While silicones may be said to derive ultimately from sand, brine, coal, and oil, their synthesis involves a number of steps and a considerable amount of industrial and chemical technology. They first reached commercial production in the form of water-white, odorless, inert liquid silicones. Two of these liquids have a low rate of change of viscosity with temperature and retention of fluidity at low temperatures, combined with inertness toward metals, coatings, and gasketing materials. These characteristics suggest that the fluids will have wide use as damping, gage, and ashpot liquids.

Excellent resistance to chemicals makes them useful as impregnants for asbestos packing and gaskets in chemical pumps; and their extremely low power loss, low water absorption, and stability to heat suggests their use as liquid dielectrics. These silicone liquids, when in solution with chlorinated solvents, can be employed in the treatment of glass surfaces or ceramic insulating forms to render them water repellent.

In resin form, silicones have a wide field of application in electrical equipment where the working life depends to a great extent upon the insulating and spacing material that is used. Because of their inherent instability to heat, conventional organic insulation materials tend to crack or carbonize, and to admit water and conducting materials when subjected to excessive

thermal conditions. While inorganic spacing materials can be used in electrical equipment, there must be temperature-stable resinous dielectrics to fill in voids, hold the conductors in place, keep out moisture, and insure good heat conductivity. This role the present silicone resins will undoubtedly fill in a great many insulation constructions.

It has been found possible, when design limitations are based on insulating temperatures, to reduce the weight of electrical equipment by as much as 50 percent through the use of silicone insulation. A comparison of two 10-horsepower motors, one insulated with the high-temperature silicone resin and the other with conventional insulating material, shows the unit employing silicones to be half the size of its mate.

AND POLYETHYLENE—Another plastics material having excellent electrical properties which was introduced to the public in 1944, is polyethylene, a hydrocarbon resin made by the polymerization of ethylene. Produced in this country by E. I. du Pont de Nemours and Company, Inc. and Bakelite Corporation, it has in its uncompounded state a waxy white, translucent appearance but may be made transparent in thin sections by quenching. Being a thermoplastic, polyethylene can be readily molded by injection or compression, or extruded to form sheets, films, fibers, tubes, and the like. In a sense, it is somewhat of a paradox. In thin sections it may be classified as non-rigid, yet it lacks the limp, rubbery quality that characterizes most non-rigid plastics. In thick specimens it is often stiff enough to be classed among the more rigid materials.

The outstanding properties of polyethylene — flexibility and toughness over a wide range of temperatures, good resistance to water and to penetration by moisture, chemical inertness, and excellent electrical properties — should find it a place in many important applications.

Regardless of the method used in producing a finished article from polyethylene, standard equipment seems to work satisfactorily. Thus, conventional plastics and rubber equipment is used for the extrusion of the resins, while conditions normally applicable to the calendering of vinyl chloride-acetate resin compounds are suitable for polyethylene after modification.

When available for other than war needs, polyethylene will undoubtedly be used for collapsible tubes for foods and cosmetics, for flexible tubing or more rigid piping, and for gaskets and battery parts. Performance under service conditions already has shown promise for use in electrical applications, applications involving chemical resistance, medical applications, molded and extruded products (industrial and civilian), packaging, applications involving fibers or monofilaments, impregnated cloth, lighting applications, and numerous unclassified applications from furniture casters to printing plates.

Research laboratories can point to an impressive record of achievement during these years of war. But not content, they already are making and carrying out plans that may have a profound effect on our way of life in years to come. It is upon the results of their activity that we in America will depend for the material items that comprise our standard of living and for many of the jobs that make our purchases possible.

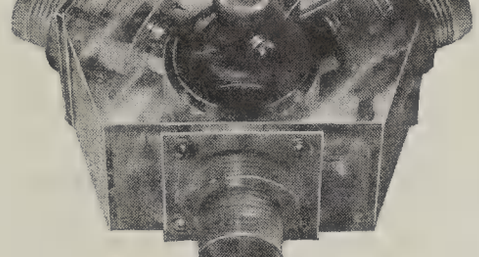
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PLASTICS MODELS

Show Exact Functioning of Intricate Mechanisms

One of the most serious problems facing industrial plants has been the rapid training of new workers, many of whom are without knowledge or experience in engineering or manufacturing practice. The Ford Motor Company has solved this difficulty with a system of teaching which makes use of Plexiglas models.

The Ford method is based on the assumption that if a transparent plastic bubble in the nose of a bomber assists a navigator in plotting his course, a



Plastics reveal inner workings

block of the same substance surrounding a metal part should enable a student to see the inner workings of a bomber's more intricate mechanisms. Experiments were started in the construction of fuel selector valves, engine-driven hydraulic pumps, and hand pumps. It was found possible to machine blocks of transparent acrylic plastics to exact specifications for assembly with other plastic parts or with functional metal parts. The transparency of the acrylic allows the interior workings of the bomber mechanism to be seen in their true perspective without recourse to prismatic projection by engineers. Instructors are thus able to explain in step-by-step detail the separate functioning of each unit and to demonstrate its relation to the whole mechanism.

PENCIL FERRULES

Made of Plastics Stand Up Under Test

The pencil chewer will have to acquire a taste for plastics. The American Lead Pencil Company has been testing plastic ferrules successfully for several years and plans to recommend them to its post-war customers.

The company's reason for this is based on the performance record of the Tenite II ferrules under test as well as the economies in material and manufacturing operations they effect. Compared to traditional copper alloy ferrules and tips made of other metals, the plastic pieces are superior in lightness, flexibility, and color appeal.

Two types of these cellulose acetate butyrate ferrules are manufactured by this company. The simpler type, used in cheaper grade pencils, is a reproduction in plastics of the old metal part. It is a simple injection molded tube anchored to the pencil and to the eraser plug by the traditional prick-punching method.

The second type, with glue-anchored ferrule, is used on the company's quality products—its Venus and Velvet pencils. The two ribs of this model, separated by a 3/32-inch depressed band, serve as borders for a brand-identifying colored stripe which is lacquered on the ferrule after molding. No prick punching mars the glossy surface and except for the lacquering of the stripe the ferrule emerges from the mold ready for assembling.

BETTER FURS

Produced By Using Chemicals Present in Natural Fibers

Sheep in mink's clothing is the best description of a new fur-treating process developed by Dr. Jose B. Calva, a Mexican-born scientist. Using his method of chemically reacting groups already present in the fibers of sheepskin and lambs wool with a reagent to form a thermosetting resin, luxurious furs can be simulated.

Such added effects as luster, curl, water repellence, wear resistance, moth-proofing, and an increase in the diameter of the filaments, can be produced by variations in the reagents.

The process can also be of benefit to the luxury furs, adding permanent luster, crease resistance, and wear resistance to rare and fragile skins. Other applications include the treatment of jute, cloth, felt, pile, carpeting, and bristles.

The treating solution used in the Calva method can be applied so that it encases the fibers to add certain properties without changing the nature of the material. On the other hand, it can be used to alter radically the nature of the fiber as in the case of sheep pelts. In this process, tanned shearlings, selected for uniform quality, are first degreased and dried. They are then soaked in water and redried.

Next, the skins are subjected to two dipping operations—first in a solution composed of 60 parts by weight of commercial cresol and 40 parts of a mixture of benzol, alcohol, and water, and then in another solution of commercial formaldehyde. After removal from the final bath the skins are put through a series of washings. Finally they are dried, and given a heat treatment which completes the formation of the condensation products.

Everything Under Control

Chains of Control, Developed Through Constant Research, Result in Better Products, Made Faster and at Lower Cost. All Industrial Production Men Have a Stake in this Important Phase of Mechanical Engineering, to Which Teamwork Holds the Key. How Plant Safety is Increased

MODERN factories make better products than ever before, make them faster and sell them for less money, all because research has been married to control. The future of all industry lies in that couple: research to find out what to do, control to make sure it is done. And of the two, control is probably the more important.

Almost any industrial product of today is produced under more controls, exercised by more people, than the production executives of 20 years ago would have believed possible. Nowadays a finished product is likely to be the result of chains of controls, exercised by groups of engineers who fully trust each other although they may never meet.

The fabrication of stainless-steel products is a case in point. Stainless steel, a tough, hard metal which for 20 years was a headache to any production man who put it through his machines, now goes down the production line with no trouble at all. And the reason is that the cutting of stainless really starts in the junk yard from which the scrap for the steel mill is purchased.

The junk yard has a laboratory. Here the scrap is tested, retested, and segregated as carefully as if it were an ingredient for a medical product. Often the yard management knows the complete history of the scrap, including the name of the steel mill which produced the original metal and the exact analysis which the metal was guaranteed to have. Fact is added to fact until the character of each bin full of chips and each bale of stamping trim becomes known.

The scrap goes to the mill of a maker of stainless steel, such as, for example, Rustless Iron and Steel Corporation. Here scrap of many different analyses will be mixed with virgin metals.

It would be easy for the steel-mill metallurgist to take so much of this scrap analysis and so much of that, and estimate that he would come out with the mixture he wants. But metals have ways of producing unexpected results when mixed. So the metallurgist must make sure. He takes fair samples of all the lots of scrap he intends to use, and melts them into an experimental ingot. Separate analyses can tell a great deal, but an analysis of an ingot tells the whole story.

Now, for a minute, let's shift the scene to the product development department of the company which is to fabricate this steel.

AIMING AT THE END—Stainless steels can be of many different analyses. Some are difficult to fabricate, others very much easier. The product development staff, aided by the sales research group, has worked out the exact qualities which the steel must have in order to result in a satisfactory end product. They have transmitted this list of qualities via their purchasing department to the steel mill. The steel-mill metallurgist therefore knows exactly what he must produce.

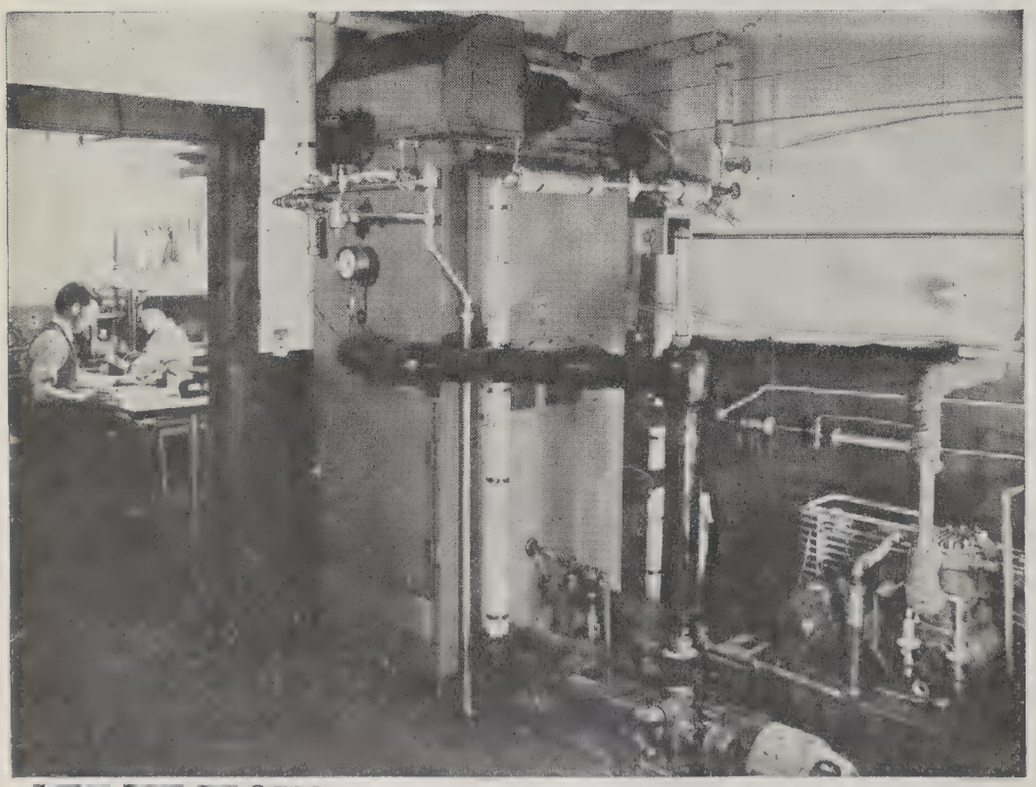
The production men are in the picture, too. Modern machine tools are capable of more exact control than any previously known to industry; they function as they are intended to function. So the production men tell the steel mill exactly how they will fabricate the metal. If necessary, a steel-mill sales engineer calls at the plant and sees the whole procedure.

This information means a great deal to the steel-mill metallurgist. Machineability (ease of machining) can be compounded into the steel.

But there are certain factors which must be observed. One of them is the matter of whether the cuts are to be deep or are to be fine. Sulfur, as an ingredient of steel, helps machineability on deep cuts and heavy feeds; it causes the chips to shear away easily and break up readily. But if feeds are going to be fine and cuts light, selenium in the steel may be more helpful than sulfur. And it is possible to vary many of the ingredients in accordance with the work to be done.

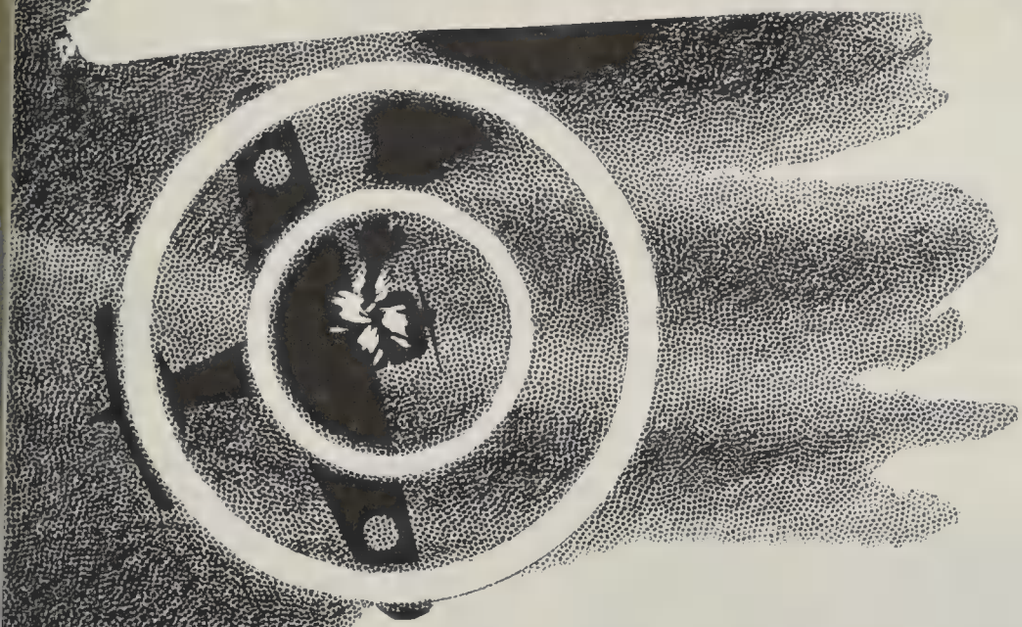
With all this information—and plenty more—in his hands, the metallurgist has his sample ingot put through the laboratory. Spectrographic analysis uses the flash from a carbon arc to excite the atoms of a tiny bit of metal. In 10 minutes a spectrum photograph sorts out the elements by their wavelengths and gives a quick but accurate picture of what the sample contains. And the laboratory with its furnaces, bunsen burners, hardness testers, and complicated glassware follows through.

The mixture finally decided upon is weighed out and put into the electric



Air-conditioning equipment (foreground) is often a laboratory "must"

CURIOUS FACTS ABOUT LIGHTING



LIKE SHOOTING FISH IN A BARREL . . . There was a time when Jap Zeros could "sit in the sun" and come in with guns blazing — protected from our gunners by blinding sunlight. Not long ago, they had an unpleasant surprise. U. S. Army and Navy gunners now have a *new Westinghouse gunsight lamp* that lets them fire with deadly accuracy — directly into the sun. Formerly, our gunners could aim within only 15 degrees of the sun, leaving a dreaded "blind spot". This has now been removed — and, with it, a lot of Japs.

Lamps of 10,000 different types, using from 1/10th to 10,000 watts — incandescent, fluorescent, infrared, ultraviolet lamps, produced at the rate of about 1,000,000 units daily — lamps for seeing, for heating, for fighting disease — *wherever you see the Westinghouse Mazda Trade Mark, you'll find top quality!*



CEILING, 2000 . . . Vital "ceiling" information is provided for American fliers by *alidade* sighting device, which "draws a bead" on a cloud — illuminated by giant Westinghouse searchlight. Height is read directly in hundreds of feet.



HAM AN' . . . New sealed-beam landing lights for army bombers are so powerful that a Westinghouse engineer actually cooked a meal on the surface of an upturned lens. Infrared rays did the trick.



DAVY JONES could find good use for this 1000-watt sea salvage lamp. Inside are loose grains of tungsten which the diver can whirl against the glass — to scour off clouding particles emitted by the filament.



SELF-CONTAINED SUN LAMP, developed by Westinghouse, produces comfortable warmth with infrared, as well as beneficial ultraviolet rays. Mercury vapor, electrodes, reflector, and incandescent filament are sealed in a reflector bulb of special glass, which screws into any lamp socket.



MAXIMUM "SEE-ABILITY" is provided by Westinghouse 3-kilowatt mercury lamps — in blimp hangars, airplane factories, steel mills, etc. These lamps produce 120,000 lumens of light.

Tune in:
JOHN CHARLES THOMAS
Sunday, 2:30 pm, EWT, NBC

Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Tune in: TED MALONE
Mon. Wed. Fri. 10:15 pm, EWT,
Blue Network

furnace. And here the control is as exact as it can be made. No longer does the steel man judge the temperature with his eye and the time for pouring by the behavior of the gases. A pyrometer with its thermocouple in the furnace measures the temperature, and the timing of the pouring is as carefully controlled as science can make it. A small sample ingot is poured so that its temperature can be taken separately and the metallurgist can have a complete record. Upon bits of evidence



Courtesy Robart Gair Company

Modern packaging design requires application of structural engineering

taken from such samples will be built tomorrow's improvements in metallurgy.

When the bars have been rolled and checks made to be sure they are of the intended analysis, another matter important to machining is taken care of—the surfaces of the bars are prepared.

CONTROLLED PICKLING—In recently bygone days, steel was pickled just enough to take off the scale, and that was that. Or it might be cold drawn or cold rolled for accuracy and to improve its surface quality. But every modern machinist knows that the skin of that steel, and what the tool has to do to get through the skin and start its cut, can make big differences to machining costs.

For one machining operation the stainless may be pickled lightly; the tools will not enter too easily and accuracy will be preserved on light cuts. For another the pickle must be deep; some kinds of tools simply will not take hold on a lightly pickled skin. Centerless grinding produces highly accurate bars, easy to turn into accurate parts, and with skins which invite top-speed machining. Cold drawing and other finishes have their places too. The point is, the steel fabricator gets the exact kind of surface which will best suit his machines, tools, and methods.

In his lathe, then, the machinist finds a bar which has been made exactly right for his task by control based upon research. But control is not yet finished.

Quite independent of the steel makers, the manufacturers of cutting oils and of tool steels have been carrying on their own exquisitely careful controls. The machine is equipped with oils and with tools exactly worked out for machining stainless steels. The oils usually are sulfur-bearing, the tools the hardest obtainable while avoiding any brittleness. The stainless will impose heavy tool loads; if it was not hard and tough enough to do this it would not be durable enough to serve in many of the products made of it.

Around him the machinist sees an array of instruments which would have bewildered an old-timer. His cutting oil is kept at an exact temperature, sometimes as high as 150 degrees, Fahrenheit, and there is a thermometer to show him what that temperature is. An electric meter shows him the amount of power his machine is using; if its needle does not point to the correct figure for each cut then he knows that something is seriously wrong. Dial gages follow every cutting tool; the machinist knows instantly if his work is becoming inaccurate. And at his elbow may be an array of inspection



Courtesy Rustless Iron and Steel Corporation

Pouring a test ingot

instruments ranging from micrometers and magnifying glasses to special templates and fixtures; no matter how many other men may be exercising controls, the individual responsibility of the machinist never diminishes.

Unlike his old-time predecessor, the machinist does not lubricate his own machine, test his own cutting oil, nor adjust his own lighting. These matters are too important to overall control to be entrusted to any one man. A special maintenance gang does the lubricating, and does it with special equipment which applies the correct lubricants and keeps them perfectly clean. Laboratory men check the cutting oil; chemical and physical tests are made with instruments. Lighting is a job for experts; the exact number of foot candles at every work plane, coupled with methods of preventing optical illusions and glare, all have been worked out by research. Cleaning the chips from the machine is a task by itself; those chips must be segregated, metal by metal and alloy by alloy, so that the cycle which started with the junk yard may be kept under control. The very cleaning of the floor about the machine is done with vacuum scrubbers which operate with machine tool precision.

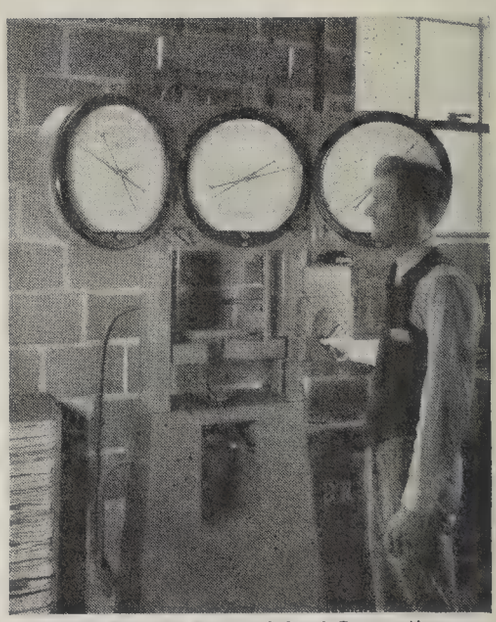
And so stainless steel has hundreds of uses where it formerly had dozens, all because the close control of all factors has made its fabrication easy.

CONTINUOUS CHECK-UP—Control by continuous laboratory check-up is another method which makes modern industry more effective. A fiber carton maker, such as the Robert Gair Company, is an example.

A fiber carton really starts its life with a study in structural engineering. Every part of the item to be packed must be protected and supported, the item must be made to contribute as much strength as possible to the finished package, no weak part of the item may bear any heavy load, and the stresses must be distributed throughout the package so they do not concentrate at any point. In fact, a highway bridge can be built with less schematic engineering than goes into many a package. But when that structural engineering is finished, the product packaged will arrive safely at its destination.

The materials of which the package is made must be exactly as specified or the structural engineering will be useless. Therefore laboratory control of those materials starts with the pulp wood, waste paper, and other raw materials and never stops until the finished fiber board is being fabricated into packages.

There is a small laboratory, or at least a laboratory man with the necessary equipment, at every important machine and process. The laboratory

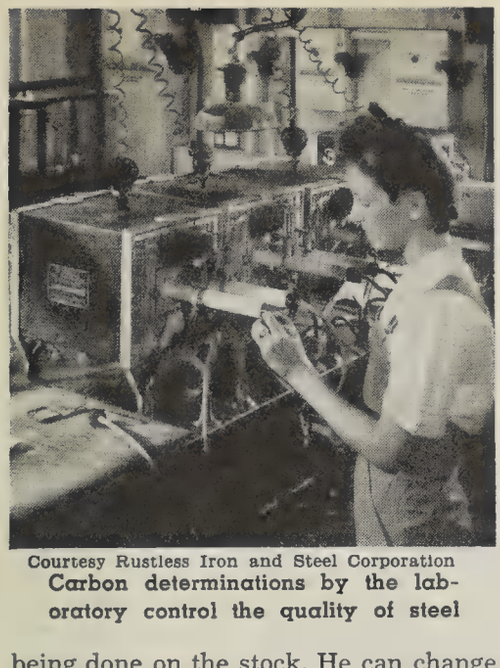


Courtesy Rustless Iron and Steel Corporation

Checking tensile strength of steel

man makes continual checks. He does not tell the production man what to do nor how to adjust his machines, but merely informs him of the immediate condition of the work in process.

The production man has at his finger tips a series of highly sensitive controls. He can change the amount of power being supplied to the machines and thus vary the amounts of work



Courtesy Rustless Iron and Steel Corporation

Carbon determinations by the laboratory control the quality of steel

being done on the stock. He can change temperatures, speeds, timings, the amounts of water being fed, or the ingredients in use. Standing at the push-button control station for a sequence of machines hundreds of feet long, he can change the coördination of that sequence to get more speed here, less heat there, higher pressures elsewhere.

A master laboratory does the final testing and lays down the original specifications by which the production men work. This laboratory continually tests the finished board, and may change its working specifications for any step in the production sequence.

Without this hand-in-hand working of laboratory and production men, thousands of tons of stock might be spoiled, or packages might have to be made bulkier, heavier, and far more costly in order to compensate for the weaknesses of faulty fiber board. But control is having its usual results. Packages are far better than ever before, and far less costly.

INSTRUMENTS TAKE OVER—Instruments are being used more widely than ever before to inform production men of how processes are working, and even to control the work directly. In fact, the 1930s are becoming known as the "instruments decade" during which mechanical and electrical controls displaced the five human senses as means for control. And the pace at which instruments are taking over is now much faster than in the '30s.

In everything from bakeries to brass mills the weather can affect the performance of processes; therefore instruments continually interpret the changes in weather and change the adjustments of process controls. Many plants making chemicals, paints, and like products are subject to wide fluctuations in the amounts of heat and power needed; instruments mounted at important machines interpret the conditions of the materials in process, translate their interpretations into predictions, and relay their readings to the power plants so that changes in the amounts of power and heat supplied may be made in advance of needs.

Instruments stand guard over hundreds of different kinds of explosion hazards, poisonous fumes hazards, and other dangerous processes; they are largely responsible for the fact that, in spite of its vastly multiplied potential dangers, industry is safer than ever before.

More than one highly complex sequence of machines is completely walled in so that its operators cannot touch it. Instruments do all of the controlling. Pushing a control switch button results in changing the settings of instruments, and the instruments in turn actuate the mechanisms which change the process controls.

And this is the future of manufacturing. Industry will grow by research, because research will be made useful by continuing development of control.

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FUEL ECONOMIES

Reflected by Reduced Haulage of Coal

IN 1918 the United States railroads hauled five tons of coal per capita per year. In 1943 (both years were war years) it was only 3.6 tons. Neither figure includes the coal hauled for burning in the railroads' own locomotives.

Very little of this decrease is represented by the substitution of fuel oil, gas, or other fuels. Any inroads these substitutes may have made into coal use are enormously overbalanced by the increased burning of fuel for power generation by public utilities and by factories alike.

These figures are direct indicators of how far mechanical engineering has progressed in getting more heat out of the same amount of fuel and making more efficient use of the heat after it is obtained.

UPSETTING UPSETS

Show Definite Gains in Forming Metal Parts

IN the many-sided "battle of the processes" for forming metal parts, upsetting is obtaining a large share of the field. While not used as often as casting, cutting, extruding, or drawing, it nevertheless is making rapid strides.

One contribution to upsetting progress is harder and better metals for dies. This means that more heads or other shapes can be upset on soft stock before tools must be replaced, and that harder metals can be upset economically.

The use of controlled atmosphere furnaces for heating parts which are to be upset has greatly promoted the art. Formerly, scale from exposure to oxygen in the air was a serious problem to parts which were to be hot-upset. Now such scale can be prevented.

Resistance heating of parts, so that the upsetting takes place at the very instant the parts were ready for it, is a development originating a few years ago. The heating is done with the parts actually in the dies and the whole production cycle can be finished and the parts in the quenching bath before scale gets much chance to form.

Induction heating is making upsetting practical for large masses of metal. In the Chevrolet Saginaw forge plant, for example, the hub ends of aluminum propeller blades are induction heated in three minutes for upsetting, compared to two and one half hours needed to heat them by gas. Such gains in speed will lead to the use of upsetting processes on many more large parts.

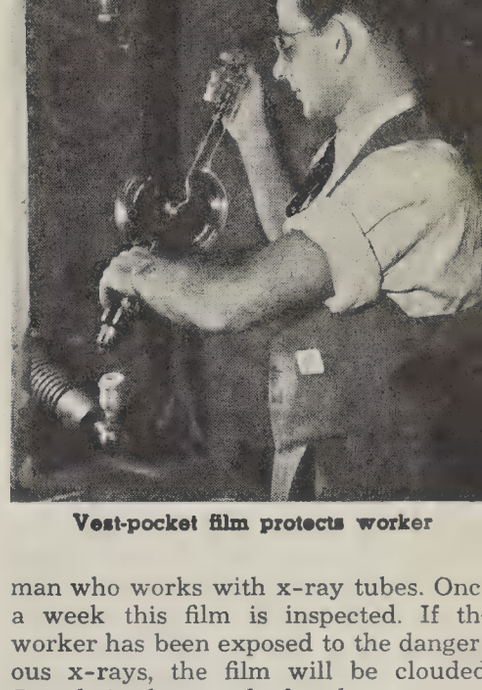
INDUSTRIAL PROTECTION

Being Adapted by a Number of Organizations

DEVICES for the protection of workmen promise to become a major industry by themselves. Many of the most forward-looking companies are well in advance of the state and national laws in their use of them.

Westinghouse Electric and Manufacturing Company, for example, uses an ultra-violet lamp to kill any fungus growths which may have been left in safety shoes during fitting trials.

Another Westinghouse ultra-advanced method is the wearing of a piece of photographic film in the pocket of a



Vest-pocket film protects worker

man who works with x-ray tubes. Once a week this film is inspected. If the worker has been exposed to the dangerous x-rays, the film will be clouded. Search is then made for the source of the danger, and correction is completed before the man resumes work.

WELDED CONSTRUCTION

Applicable to a Number of Different Types of Projects

A DIVERSIFIED application of electric arc-welding to practically any type of steel construction for projects adaptable to peace-time purposes is forecast in a recent issue of *Construction Methods*.

An all-welded steel swimming pool is durable and usable with little care. An all-welded storage sphere for liquefied natural gas kept at a temperature of —258 degrees, Fahrenheit, has been constructed with an inner sphere welded of a special alloy steel, using

shielded-arc electrode specially designed for welding various stainless steels. This procedure guarantees that the containers can be kept at extremely low temperatures without fear of fracture. After the war, liquid natural gas may be shipped in tank cars, barges, and ships, making this important fuel available in many additional areas.

An all-welded bus garage of extremely light construction is provided with long-span trusses, permitting a large, unobstructed repair area underneath without vertical support. A special tank, or "vertical bullet," used for the storage of highly volatile gases in the petroleum industry has been built by arc-welding. Increased use of high octane gasolines after the war may cause a growth in this type of fabrication.

Welded fabrication has been found to reduce maintenance materially and give a factor of safety in a rigid-frame all-welded steel building. The completed structures cost substantially less than was indicated by bids for other conventional types.

CORNERSTONES

Aid in Improving Industrial Construction

New industrial materials come along so fast nowadays that many a plant management has trouble in keeping track of what materials were used for various purposes so it can know what values each material proved itself to possess.

One user of high-temperature processes has to tear down its furnaces when they are badly worn. It has trouble, however, in remembering what materials were used in them, since the life of a furnace between teardowns may be more than two years. The problem has been solved by putting, in a corner of the furnace remote from the heat, a hollow block in which is placed a list of materials used, the building method, and blueprints. Comparisons of these data with the repair and maintenance records, and with the condition of parts of the furnace when torn down, give the data needed for more durable rebuilding.

LANDING STRIPS

Will Land New Jobs in Many Industries

The steel landing strips which are laid on the runways of new military airports, on invasion beaches, and the like, may have an important peace-time future.

One expected use is for secondary roads. The steel strips are laid, then filled in with mixtures of sand and oil, rubble and tar, and the like.

Roads of this type may be laid for temporary as well as permanent use. When a main arterial highway is being rebuilt, for example, the "one way only" and "pass at your own risk" strips which contractors must keep open, are as expensive to contractors as they are bothersome to motorists. Much of this trouble may be saved by laying temporary landing strip roads, and the method may pay for itself out of savings in the costs and time needed for rebuilding the main roads.

Some types of factory floors offer other uses. Where there are heavy castings which must stand and cool, for example, a readily replaceable mat of heat-dissipating steel beneath a shielding layer of sand may offer great advantages.

Chemicals and other plants which make use of process muck to fill in swamp or waste land, are eyeing these landing strips with favor. The strips will permit temporary roads to be laid for dump trucks, make the handling and piling of the muck for the smoothing bulldozers easier and less costly.

SALVAGED BTUs

Show Profits in Far-Sighted Industries

Industry is coming out of this war with greatly advanced techniques for salvaging and using heat units.

More heat than ever before is being generated in melting, grinding, welding, and other processes. Less of it is being wasted by exhausting heated air to the atmosphere or running heated liquids to the sewer.

One long-time technique is to run dust laden air from grinding machines through filters, remove the silicosis-dangerous dusts, then return the cleaned air to the work zone. Since the air has been heated largely by the friction of the grinding operation, the BTUs contained in it are salvaged materials. The savings in plant heating bills often pay for the cleaning of the air and then show a profit. One electrical products plant estimates that it saves 800 tons of coal a year in this way.

Another method is to run water, heated while cooling rolling mills, direct to metals washing tanks which must have their water supplies kept at above 150 degrees, Fahrenheit.

Offices, and even the nearby homes of workers, are heated by steam or hot water piped from heat-producing processes. The water is recirculated to the process tanks.

Waste heat is used to preheat metals before flame cutting, to heat thermoplastic materials before molding, to preheat metals before abrasive blasting, to heat baths used in plating, to heat water used in the processing of textiles, and for dozens of other purposes.

Often the salvaging of heat units adds tiny weights and secures delicate balances in the economies of the production line—economies which pay off in their total effects upon profits.

REMOTE CONTROL ON THE HOOF

Enables Operator to Select Advantageous Observation Post

As more and more machines are connected together into continuous processes and as mile-long continuous conveyor systems become commonplaces, the problems of remote control and of mid-point temporary adjustments of speeds, and so on, are on the rise.

The most common control method is to have variable-speed motors, variable-speed power transmission drives, and the like, spotted along the chain of integrated machines. Skilled operators then can change operating speeds as needed to keep the continuous process functioning.

One trouble with this has been the tendency for unskilled men to monkey with the controls. Often the adjustments in operating speeds, although made with the utmost of good intentions, have very bad effects.

Another trouble is that it may be impossible to locate a push-button station at the best post of observation for the operator, since that post is wherever the trouble—the conveyed material pile-up or whatever—occurs, and this is largely a matter of chance.

One way of handling both troubles is to hang a push button electrical switch box on the belt of the operator. Leads from this plug-in at the control stations, and since no other buttons are located at these stations, unauthorized personnel cannot operate the controls.

The operator carries spare lead wires which are long enough so he can plug-in at the regular control station and then stand several feet from the station while manipulating his switches. He thus can do his controlling from a place which gives him the best view of the trouble he is correcting.

WOODEN DIE BLOCKS

Are Inexpensive and Increase Speed

Wood fiber processed by the Masonite method is capable of being given wide varieties of hardness, weight, water absorption, and other characteristics. Many of the resulting products are military secrets, but one which has come to light is the wooden die block.

This block is compressed to such hardness and weight that it will not float in water. But it can be cut and shaped to a smooth finish and it will hold its shape under changing temperatures.

One principal use is for dies on metal spinning machines. The wooden block costs only a few dollars to finish into a die, whereas metal blocks may cost hundreds of dollars. Once shaped, the wooden block provides a surface over which the metal flows very easily, in some cases materially decreasing the labor and increasing work speed.

Large pieces, such as sections of airplane wings, also are shaped over these blocks. The use of wood in large sized bending brakes is old in the sheet metal art; many mechanics preferred the friction characteristics of metal over wood to metal bent over metal. One of the old troubles was the non uniformity of the wood. With this new product—and perhaps other wood dies to be made of lumber prepared by the new Du Pont and other processes—wood may be an important factor in the tools of the intricate shaping sheet metal industry of post-war days.



The synthetic rubber industry is a product of chemical research. This partial view of Koppers United Company's Kobuta plant gives an idea of its immensity

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER

Where Research is King

In the Chemical Industries More than Any Other Field, Research is the Basis of All Progress and Profit. Outstanding Among its Achievements Has Been the Drastic Lowering of Prices on a Long List of Materials Used Widely in Production, with Consequent Benefit for All Humanity

By F. J. VAN ANTWERPEN

Associate Editor, *Industrial and Engineering Chemistry*

THERE IS nothing in chemistry today that research has not affected. This is another way of saying that there is nothing in your life which has not been influenced by this same force. Research has been defined as "a state of mind." The field of chemistry, with its many offshoots—industrial as well as theoretical—well represents this state of mind. Fortunately, this state of mind has paid immense dividends both in dollars declared to stockholders and in discoveries basic to progress.

Although research is continually concerned with the development of new and better things for mankind, not the least benefit to come from the application of the research method is the reduction of prices to the consumer. The chemical industry is a long-time champion in this respect.

It was said recently that the cost of triptane—marvelous new fuel—was $1000 a gallon when it was first produced on a laboratory scale. Pilot-plant trials brought the cost down to $35 a gallon and recent experiments have perfected a process that is going to make this tremendously powerful gasoline for less than a dollar a gallon.

COST REDUCTIONS—Research has also lowered the prices of certain chemicals as follows:

Acetanalide cost 66 cents a pound in 1918; now it costs less than 23 cents.

Acetone cost nine cents in 1934; it is priced at four cents now.

Ammonia has been halved in price in 30 years.

Aspirin fell from $3.26 in the last war to less than 47 cents in this.

Cellophane cost $2.65 in 1924 and research has reduced this to about 30 cents today.

Coal-tar dyes, short in 1918 at $1.07 a pound, are plentiful today at about 61 cents a pound.

Benzyl alcohol reached the stratosphere during the World War I shortage at $6.25 a pound. With the proper priorities you may buy it now at 51 cents.

Chile, at one time, with a corner on iodine in the world marts, forced the price to well over $4.00 a pound. Several chemists out west, noticing tha oil-well brines had a high iodine con tent, devised a process to recover th halide and Chile's monopoly wa crushed for all time, as was the exorbi tant price.

When dry ice first appeared the pric was close to 4 cents a pound; by 193 it had come down to 1.5 cents.

In six years cellulose acetate price fell 20 cents a pound.

Hydrogen gas has dropped from $6.8 to $1.38 a thousand cubic feet in 1 years.

Obviously, only the application intensive and deliberate research coul produce results such as those describe above. It is a long cry from the attitud of early industry when manufactur ing was an art, techniques were hande down from father to son, and not jot or tittle could be changed. Toda research deliberately attempts to fin improved manufacturing methods an cheaper and more available raw ma terials—all dedicated to making a fin ished product that will be accepte more readily by the public. Research a powerful tool that is busy at a times creating new industries and ne comforts for mankind.

UNPREDICTABLE RESEARCH—Arthur Little, one of the men in America wh sold the necessity of research to indu try, once said that research had on characteristic in common with lightnin — one never knew where it wou strike. In analyzing that stateme

another aspect of research is seen—that, even though research is generally planned along certain lines, the results are never certain and a successful research organization must be able to capitalize on whatever new facts are turned up.

Chemical research has always been able to do this, from the day when the boy who was later to become Sir William Perkin, trying to synthesize quinine, found the coal-tar dye industry in his test tube, down to the present, when a food concern improves mechanical greases or discovers a material that will purify water.

In early 1939 several German scientists toured the country inspecting the industrial plant of the United States and at the end of the tour they were asked what had impressed them most in all they had seen. Their answer is a tribute to the greatest institute that has ever been developed for research; the thing that filled them with envy was the Mellon Institute and the close co-operation which it fostered between research and industry. To them that was the crowning achievement — only to be found in a country where industrial progress is a continuing thing — upon which general prosperity is dependent.

There is nothing new in organizations dedicated to research. The Germans had them. The uniqueness was to be found in the co-operation between industry and the scientist—proof that the intangible basis of research *is* a state of mind. The donors of the money that founded the Mellon Institute had recognized that research was a necessary condition to the general welfare of the country. Andrew Mellon said: "It is science, not governments nor wars of conquest, that opens up to us new horizons." Mellon recognized other truths concerning business and science when he stated that "improvement in the standard of living of the human race can come about in the future only by reason of new discoveries and inventions, just as in the past the steam engine and other inventions have been responsible for many improvements in the standard of living enjoyed by the average man today. It is these things and not governmental or political action that have increased production, lowered costs, raised wages, elevated the standard of living, and so have brought about a greater participation of the human race in these benefits."



A General Motors' Diesel on a test stand where many thousands of hours were spent on lubrication research

FINDING THE UNSOUGHT — Chemical research as practiced at the Mellon Institute has fully met the expectations of the founders. One example will be given—the most famous, perhaps, of any example that could be chosen to illustrate research and the queer twists that may be expected from it. As in many research problems, the chemist was looking for one thing and found another.

Dr. George O. Curme, working for the Prest-O-Lite Company on an industrial fellowship, was seeking better ways to produce acetylene, the gas used in oxy-acetylene welding and cutting torches. The method then in vogue for generating the gas depended upon the reaction of water on calcium carbide.

Curme soon found that acetylene could be produced by cracking gas oil. The one drawback was that ethylene —an unwanted by-product—was formed also. If the process was to be economical, it was necessary that an industrial use be found for ethylene, and research was started to find some outlet for that by-product. The outcome was the anti-freeze that you probably use in your car — ethylene glycol. This same material is also used in the explosives industry and is serving purposes entirely new to the arts. Its ethers are ideal solvents and are finding irreplaceable (until further research topples them) applications in the lacquer field. And from the researches on acetylene has today grown the mighty Carbide and Carbon Chemicals Corporation.

The list of chemicals developed by this corporation from the application of intensive research methods is longer than your arm. The young man who made the original discovery is a vice president of the organization and still its sparkplug in research. Upon these basic researches is founded an industry producing organic chemicals from petroleum gases. The same Carbide and Carbon Chemicals Corporation has been making ethyl alcohol from the ethylene of natural gas for many years. This was another triumph of research, for it had been predicted freely that such a process would never be economical in the face of alcohol from fermenting blackstrap molasses. Research paved and proved the way.

PROFITABLE BY-PATHS—The paths along which the state of mind just exemplified may lead a company are strange indeed. The Eastman Kodak Company, conducting research on problems basic to the photographic business, found itself with a highly successful means of producing vitamins. A technique that was investigated by the Eastman laboratories was that of high vacuum distillation. The investigators soon found that the methods, developed for the study of a problem dealing with ways to improve the taking of a picture, were also conducive to making vitamin A by the distillation of natural oils.

The same company is a large producer of cellulose acetate yarn—a business that stemmed from production of safety film. And that compound pays dividends from its use as a thin, transparent wrapping material.

The photographic business leads inevitably to plastics, for the inventor of the phenol-formaldehyde type plastics,



Courtesy Westinghouse

Research is seldom wasted. This elaborate set-up was made for the purpose of testing the insulating qualities of paper used in radio condensers under extreme heat and cold

Baekeland, was also the inventor of Velox photographic printing paper. If any industry can be considered a product of research, certainly the plastics industry can be. It began when a young man experimented until he found a substitue for ivory, and received its great impetus when Baekeland invented, through research, his famous plastics. The industry is continuing on the same basis—research—and is making the older plastics stronger and cheaper; the same state of mind is bringing out more and more new plastics for newer applications.

The ancient and honorable field of textiles also yields to the organized search for knowledge and improvement. An example from this field serves again to illustrate the tenet that everything is grist for the research mills. A textile chemist has no real business worrying about the tarnishing of silverware, but the intellectual curiosity of such men will always provide progress. Silver tarnishes because the sulfur gases in the air combine with the silver to form silver sulfate, the black film that sends good house-

wives into dithers. One solution hit upon was that of impregnating a flannel bag with metal salts, but research soon proved that the sulfur that formed as a sulfate on the metal salt moved, in time, to the interior of the bag and caused an even greater formation of film. The final answer to the dilemma was to saturate the flannel with silver itself, and millions of the tiny pieces of metal are incorporated into each bag. The sulfur in the atmosphere combines with the metal in the bag and the result is to protect the eating implements. Lightning strikes in strange places and a state of mind can lead along unorthodox paths.

BASIC RESEARCH—There is an untold debt that civilization must acknowledge to so-called basic research. The development of nylon owes its success to the pure research done by Carothers in the field of polymerization. The synthetic nitrogen industry traces itself back to the experiments made by Dewar on the liquefaction of air, and the glowing neon signs that light up the city are direct descendents of Sir William Ramsay's experiments on the densities of nitrogen.

Can anyone adequately sing a paean of praise to a force that has to its credit the many chemical wonders that are seen on every side? In two wars research in the chemical field has fought to a standstill the shortages threatened by blockade. In World War I there were shortages of dyestuffs, potash, drugs, anesthetics, and many other materials. In this war the shortages were rubber, tin, antimalarials, and high-octane gasoline, and additional manufacturing capacities for aluminum and magnesium had to be provided. In each case the victory was won. Research proved it could be done and industry proceeded to fill the empty warehouses.

The story of research is always dramatic. In the last war there was an acute shortage of aniline. According to the Germans, we could not hope to make this material because benzene from American coal wasn't the right kind. This palpable nonsense impressed our chemists not one bit, and by 1917 we were producing 37 million pounds of aniline per year. Research is, after all, only observation and deduction, and these qualities brought a happy solution to a serious problem.

Research may be a key to the unknown, but it is a key that requires a great deal of turning. Results in research are not usually obtained by waving a wand or appointing a crew of chemists as research workers. Results are usually obtained by the investment of patient money over a long period of time.

No story on research illustrates this better than the discovery of tetraethyl lead by Thomas Midgley, Jr., who was one of America's most capable chemists and who recently died a tragic death. The discovery of tetraethyl lead, according to Midgley, is only one part of another major research problem still continuing—the improvement of the automobile. Even after tetraethyl lead was discovered, there still remained the problems of reducing production costs and proving beyond question that there was no health hazard in its use.

In the words of Midgley, tetraethyl lead was a "tough uncompromising problem . . . possible only because courageous corporate executives had the foresight to invest large sums of money and continue backing an idea . . . when less astute minds might have dropped it . . . With only slightly different circumstances the whole project of ethyl might have been written off at one time as a $3,000,000 flop."

Such is research. Truly, it is a state of mind found only in men who will back to the hilt an investigation into the unknown, looking for an intangible something that will solve a problem not yet defined, to give to mankind benefits they do not expect.

RESEARCH IN WONDERLAND—There is a delightful bit of nonsense in Lewis Carroll's "Through the Looking Glass" which may well represent all industrial research. Alice was in the garden of live flowers talking to the Red Queen. Suddenly they both were running hand in hand. (From here on the Red Queen is Research and Alice is the Public or Industry or what have you). The Queen went so fast that Alice could just about keep up. Still the Queen kept crying, "Faster! Faster!" The most curious part was that the trees and other things around them never changed places at all. However fast they went, they never seemed to pass anything. "I wonder if all the things move along with us?" thought poor puzzled Alice. And the Queen seemed to guess her thoughts, for she cried, "Faster! Don't try to talk!"

Finally Alice managed to pant. "Are we nearly there?" "Nearly there!" the Queen repeated. "Why we passed it ten minutes ago! Faster!" On they went, the Queen urging "Faster Faster" —and at last when they did stop Alice discovered that they hadn't covered any territory at all—they were yet in the same place. Upon commenting upon this phenomena, Alice was surprised to hear the Queen say that it was what one could expect.

"Well," said Alice, "in our country you'd generally get to somewhere else —if you ran very fast for a long time, as we've been doing."

"A slow sort of country," said the Queen. "Now here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

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SUBSTITUTE PLASMA

Realized Through Use Of Ion Exchangers

ION-EXCHANGE resins have a possible new war-time use, it may now be revealed. Newest application of these chemical materials promises to be the purification of pectin and gelatin f use in the preparation of substitu blood plasma. Substitutes for blo plasma are being developed because shortages, and present indications a that pectin and gelatin will serve temporary and partial replacements.

The ion-exchange materials elim nate unwanted salts from supplies the substitute blood. Salts which c be eliminated are calcium, sodium, a senic, and lead. It is possible, throu the use of the ion exchangers, to elim nate completely the salts normally pre ent in water, the finished product bei similar to distilled water. The prese application is a continuation of th technique.

FAT SALVAGE

Has Averted a Soap Shortage

FATS and grease saved by the hous wife come back to her in the fo of soap. The successful campaign collect these materials from the hom of America has paid a handsome div dend to the citizens by preventing soap shortage.

The war, which cut off the norm supply of coconut oil, presaged a di cult time for the soap maker. He h been forced to use substitute oils a fats, and the changes have in ma cases forced a revision of formula. La a fat seldom used in the soap field, w one of the materials that offered its and 74 million pounds were used 1943. Resin entered into all soaps fo time, but shortages have cut into use.

The housewives, above all, help considerably and the amounts kitchen grease normally consumed the soap industry have been increas 54 percent. At the same time, materi obtained from the waste fats have do their job in munitions and medicin production.

GLASS TOMORROW

Will Perform Many New And Strange Duties

A POST-WAR age of glass, in which n and strange duties will be performed that material, is predicted by Profe sor Alexander Silverman, head of t Department of Chemistry of the U versity of Pittsburg and one of t nation's leading authorities in gl technology.

Glass will be used to reduce heati costs, to bring clearer movies, to help the cooking of dinners by lamp rad tion, and possibly to harness the su rays for heat and power, according Professor Silverman.

The glass industry, he said, now v ued at $500,000,000 in the United Sta alone, has made more progress manufacture and technology in the l 50 years than in the thousands of ye before. The war, Professor Silverm adds, has hastened many developme most of them yet secret, that will br transformations in the everyday mo of living.

Research In Metal Heating

Cheaper and Tougher Metal Parts for Many Uses are Expected to Follow as a Result of Research at a New Laboratory for the Development of Wider Applications of High-Frequency Induction Heating to the Tasks of Metal Hardening, Brazing, and Annealing

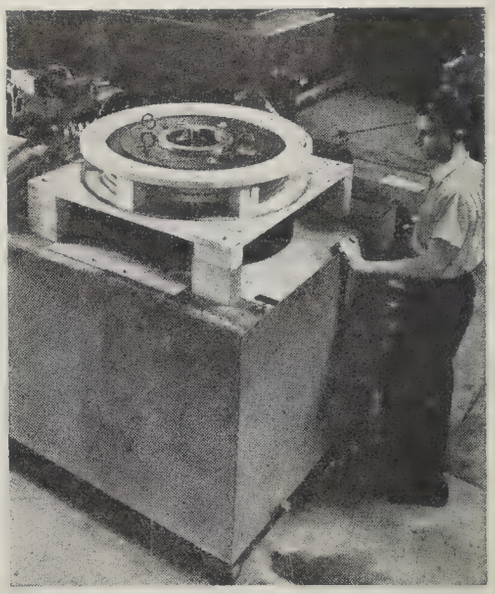
WIDER fields for induction heat-treatment of metals are expected to be opened as the result of the recent completion of a new high-frequency experimental laboratory by the Tocco Division of The Ohio Crankshaft Company. Its facilities enable full-scale experimental work on applications for the hardening, brazing, annealing, or heating for forming of both ferrous and nonferrous parts of varied size.

Power supplies available in the laboratory include 333 kilowatts of 1000 cycle current, 1000 kilowatts of 2000 cycle current, 300 kilowatts of 3000 cycle current, and 335 kilowatts of 9600 cycle current. Power is controlled by a four-way standard-type panel board governing each of four generators that produce the high-frequency current.

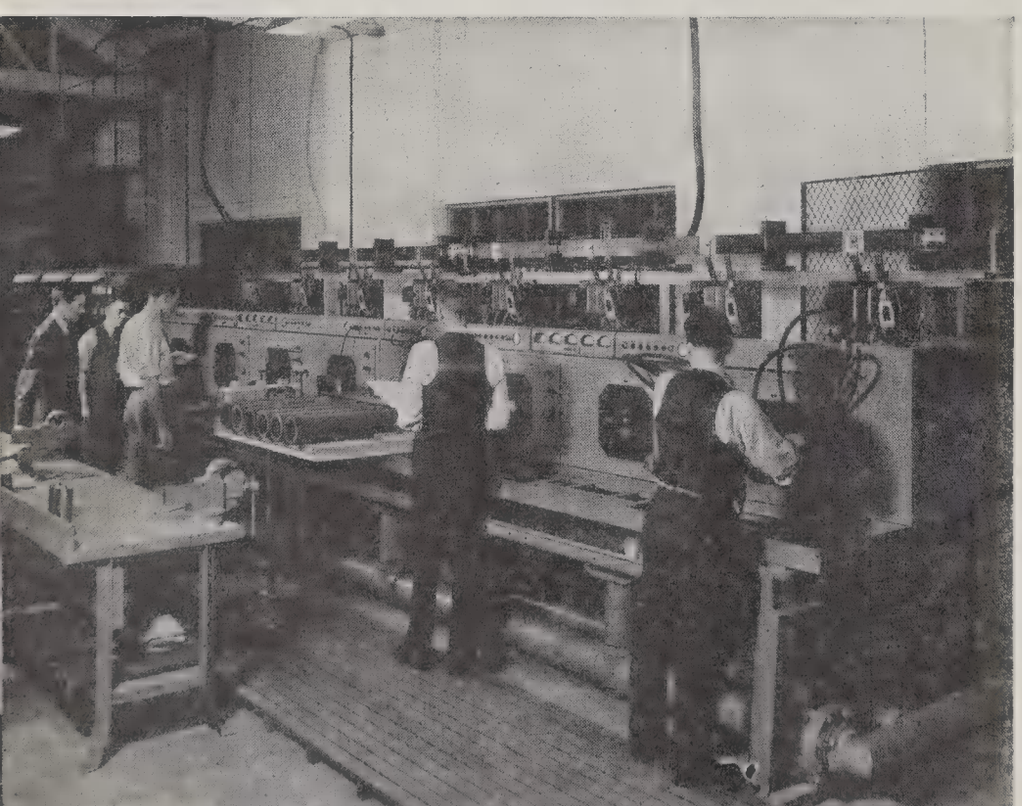
Experimental induction machines are of varied styles and capacities, the most distinctive being an eight-station, panel-type unit of 9600 cycles, 25 feet long and six feet high, having automatic controls. Each station is equipped with a different turn-ratio transformer for maximum experimental usefulness. Here various tests can be run simultaneously without interference or delay. Physical dimensions of the work area of this large unit coincide with standard Tocco machines, facilitating development and testing of new fixtures and inductors.

The progressive hardening of bars and tubing is carried out on two machines, one hydraulic and the other mechanically controlled. In the mechanical style the piece remains stationary while the inductor moves up along the bar to be treated. These two units, which really are fixtures operating on 9600 cycles received direct from the generator, have facilities for obtaining maximum range of speed and power depending upon requirements of parts under test.

Experiments on big parts, crankshafts, steam-hammer rods, generator shafts, and the like, are made on what is termed a "tunnel line" because of its long sheet-metal hood. This is a four-station unit, 20 feet in length, ruggedly constructed, and equipped with a moving cradle set on a track to hold test parts positioned in the water-cooled inductors. Each station is equipped with automatic and manual control devices. Power frequencies of one, two, three, and 10,000 cycles give the tunnel line the ultimate in induction flexibility.



Hardening a 26-inch gear in the special experimental unit. The induction heaters can be changed to accommodate different sizes of gears



Eight-station test panel used for experimental inductors and special heat-treatment applications. A variety of tests can be run without interference between them

Another special test unit is that for gear hardening. It is a five-foot-square box-like fixture, five feet high, with full automatic control devices, and with a circular inductor which can be changed to accommodate a new size. A quenching mechanism is set in the center, providing water or oil quenching.

POST-WAR DINING CARS Will Feature Diagonal Arrangement of Tables

PLANS for a post-war railway dining car embodying diagonal seating and possessing the "atmosphere and appointments of a fashionable club" have been prepared by the Pullman-Standard Car Manufacturing Company.

The outstanding feature of the car is its floor plan which is arranged to accelerate service, to eliminate inter-

ruptions caused by arrivals and departures at the tables, and to enable waiters to step to the side when serving so that aisles are free at all times. Other innovations include vibrationless tables, spot-ray illumination, linen storage at each table, and intercar telephone communication.

Tables, which have a total capacity for 42 persons, are placed diagonally and seats are set at a 45-degree angle to the side of the car instead of at right angles as in ordinary diners.

"One of the greatest benefits accruing to the traveler from the angular seating arrangement," according to Ellis W. Test, Assistant to the President in charge of Engineering and Research, "will be unobstructed movement. Each person will slip into his seat or leave the table without disturbing his neighbor. Everyone will have a side of the table to himself and enjoy a normal conversational position instead of knocking elbows as at ordinary diner tables.

"At the same time, each one will view the passing scene without even turning his head. The diagonal arrangement will permit waiters to step between the tables when serving, and they will serve from the side instead of reaching over the person occupying the aisle seat as is necessary in the old diners."

CRYSTALIZED LIGHT

Brings Closer an Understanding of Electricity

BY TRANSFORMING electricity directly to light, a phenomenon common to fluorescent tubes and vapor lamps, "we have freed electricity in an uncrystalized form," a Westinghouse lighting authority recently told The Franklin Institute.

"Fluorescent tubes, mercury vapor lamps, and the various other new electric lamps which produce light without the intermediate step of heat, as represented by a hot incandescent wire, simply develop uncrystalized electricity so that it goes out as radiant energy," said Samuel G. Hibben, director of applied lighting for the Westinghouse Lamp Division.

The lighting specialist expressed the belief that these new "quasi-electronic methods of illumination, which produce light by sending an electrical discharge through vapors, should bring us closer to understanding what electricity is." Light is uncrystalized electricity or, stated another way, electricity is crystalized light, Mr. Hibben said.

SALT BATH FURNACES

Anneal Brass on Production-Line Basis

A FULL anneal of brass cartridge cases on a continuous production heat treating basis is being accomplished with what are said to be the longest continuous conveyor-type salt-bath furnaces in operation in America, and with an unequalled absence of oxidation.

In addition to the expected reduction in costs of operation, plus the increase in speed, the feature of the operation which employs Upton Electric Salt-Bath Furnaces is that the anneal on the brass is not only a full one but it is absolutely bright as well.

While this has been attempted on other occasions, it has never before been accomplished to the extent that the cases come out of the heat treatment clean and bright and without the slightest trace of oxidation, so that pickling or other cleaning is not required following the anneal.

Two furnaces are employed, each capable of annealing 6000 pounds of brass every hour. One gives the cases a full anneal at 980 degrees, Fahrenheit, before the nosing operation. The second furnace full anneals the cases at the same temperature after the nosing operation.

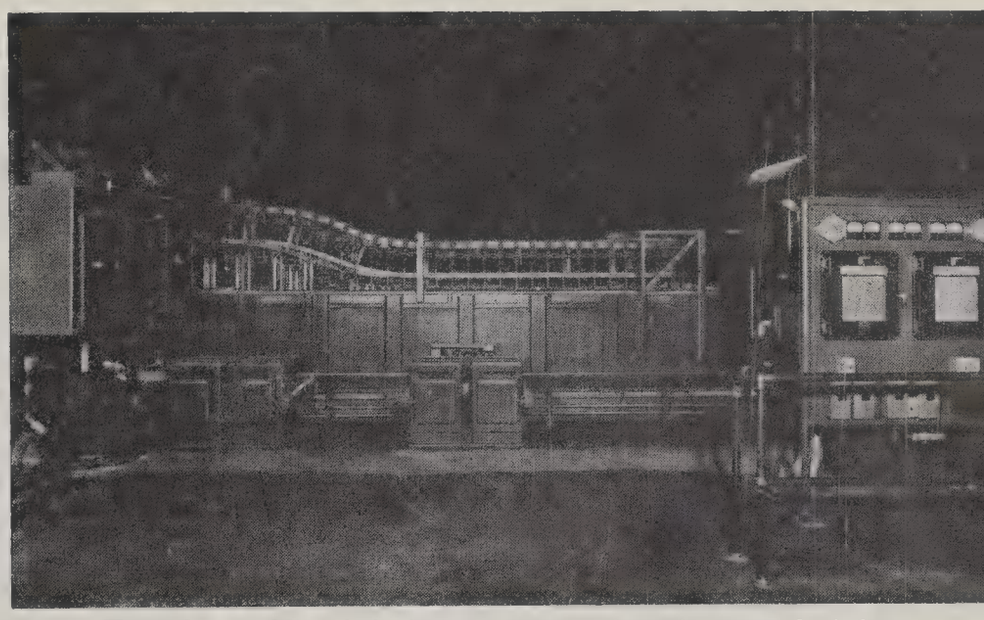
Each of the two furnaces replaces ten individual non-continuous-duty furnaces previously used and with such savings that the management of the Detroit concern where they were installed is reported to have stated that "the furnaces paid for themselves in the first three weeks of operation."

The annealing operation is not only continuous but entirely automatic, with the exception of the occasional shovel full of salt required to replenish the salt lost through normal operation and from the nominal drag-out. The temperature of the bath is held within ±5 degrees, Fahrenheit, by automatic electric temperature control.

The first furnace to be installed was equipped with removable covers with the idea that sufficient heat would be radiated from the salt to make them advisable. Salt is added through a small door in the covers at the turn-around end of the furnace.

The second furnace installed is not equipped with covers since, through experience, it has been found that the amount of heat lost is so small as to be not worth even the small additional expense.

Uniform temperature throughout the entire bath is made possible largely through the placement of electrodes which enter the sides of the furnace instead of being thrust in from above the surface of the salt. These electrodes, which conduct the current into the bath from the transformers loca outside the furnace, are so positio that the transfer of current through salt generates the heat at the bott of the pot rather than anywhere ab that point. The result is that a nor flow of heated salt circulates upwa thereby heating the entire content the bath evenly and uniformly.



Electrodes in this salt bath furnace enter the sides instead of the top

HOME WORKSHOPS

Will Probably Increase in Number After the War

HOME workshops, either for hobby business, will have a place in m than 60 percent of all homes after war, reports the Delta Manufactur Company, designers of power tools, a result of a survey just completed.

An interesting fact brought out the survey is that the majority men and women in the armed servi are planning now the homes they tend building after the war. They reading any and all literature deal with home building and are intens interested in new developments c culated to make homes more livea and easier to maintain.

The excellent mechanical train the Army and Navy has given to personnel reflects itself in a desire the part of these men and women continue using their newly acqui skills when they return to civilian both to create objects of beauty the home and to keep down the c of home maintenance.

Civilians are equally anxious for formation to aid them in future ho building. It was noted that men, especially women working in plants, have been agreeably surprised find that they have first class mecha cal ability as shown by the many div sified products they have created. Th persons indicate a wish to apply aptitude for their personal use home in the fabrication of many ticles of wood, plastics, and metal.

It has been the experience of ho owners that, for a fraction of nor market cost, they have been able build excellent storm windows, bo cases, kitchen cabinets, and even co plete sets of furniture for the en

house. With the high cost of labor and the acute shortage that is expected to exist for some time after the war in many of these products, home owners state that they intend to construct many of these articles themselves. They have found that, with a small number of inexpensive power tools such as a table saw, drill press, lathe, and sander, repairs and additions to the house can be completed economically in a professional manner in a fraction of the time it would take to do the job with hand tools.

COMPREHENSIVE EDUCATION

Needed by Embryo Industrial Scientists

In addition to the scientific course which they are given, it is important that students preparing for a career in science should be taught to express themselves, says Dr. Saul Dushman, assistant director of the General Electric Research Laboratory in the *American Journal of Physics*.

Writing on the subject of "Post-War Training of Physicists for Industry," Dr. Dushman says it is often forgotten in connection with the training of physicists, and of scientists in general, that "progress in science as well as other branches of human endeavor depends ultimately upon the ability to communicate ideas to others by means of language. Whether it be the exposition of an idea by word of mouth, or the description of experimental observations in a paper for publication, clarity of expression and logical presentation of data and conclusions are prime requisites. It is not required of the scientist that he be either an orator or a clever wielder of $64 words, only that he express himself clearly in everyday language and use this language correctly."

The role of the physicist in war-time developments has shown that he can be very practical, Dr. Dushman declares.

"Industry has learned through the experience of the past few years," he writes, "the fact that physicists are capable of contributing to, and initiating, fairly complex engineering developments. The design and operation of a cyclotron requires a technical skill such as compares very well with that required to design and operate high-voltage generating equipment. The physicist has indeed demonstrated by his activities in the war effort that he is not the theoretical recluse intent only upon some abstract objective; that, in fact, he can become under proper conditions just as practical and just as hardboiled as any industrial engineer. In view of these considerations, it would seem reasonable to suppose that in the post-war world there will be a much greater demand for physicists in industry than in the past."

Such industrial physicists must know other subjects besides their basic physics and mathematics. "The physicist in industry," Dr. Dushman continues, "must be versatile and adaptable. In view of the increasing complexity of materials and operations used in industry the physicist should also know considerably more chemistry than has been the case in the past. Indeed, I would like to suggest that the proper course of training for an industrial physicist should be one that would comprise almost as much chemistry as physics."

CONTINUOUS MOLDING

Achieved in Machine that Handles Plastics or Rubbers

A continuous injection molding and extruding machine, the only known device of its kind in the world capable of producing an unbroken seamless tube of any kind of plastics or rubber and of any length, has been developed by engineers and technicians of Chrysler Corporation. One of the machines —in use by a licensee in another state —is producing seamless plastics tubes to launch rockets, and another one is ready to mass-produce rubber insulators. An experimental machine in the corporation's Engineering Division has produced hundreds of plastics and rubber parts and articles.

The new machine, which employs a worm screw similar to those found in coal furnace stokers, has undergone extensive tests and has shown that it can step up the manufacture of many thermo-plastics and thermo-setting plastics, and real and synthetic rubber articles, at least ten fold. Because of the quadruple field the single machine is capable of covering, the range of plastics and rubber parts and articles, in much larger sizes than realized under previous manufacturing methods, is apparently very great.

The machine has produced as large an item as a plastics battery case in less than five minutes, using 128 ounces (eight pounds) of thermo-setting plastics. No other machine is known to be capable of injection molding an article of this material weighing more than 36 ounces. It has produced at one molding in less than three minutes as many as 144 rubber insulators. It is also capable of producing precision rubber parts for many war products.

In the tubing field the machine has enormous possibilities. Thermo-setting plastics tubes, made in any lengths desired, can be used for overhead and underground pipelines. The thermo-setting plastics is highly resistant to corrosion, and in some cases can replace steel and iron pipes with lesser resistant qualities. Where long lengths of iron, steel, or concrete are necessary for rigidity, thermo-setting liners produced by the machine would provide resistance to corrosion.

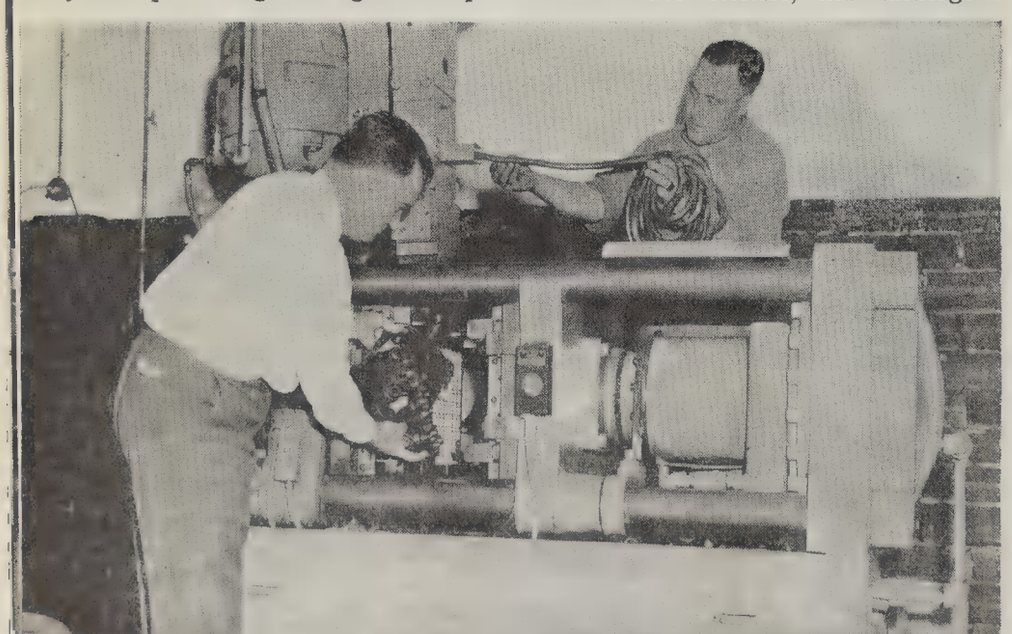
Under the conventional compression molding method, plastics or rubbers are placed in a die by hand, and pressed into shape by clamping another die to it. To insure adequate material



Some of the many articles that can be produced by continuous molding

in the finished product, more than enough is inserted in the die cavities. Under pressure the excess material forces itself out through cracks where the die faces join, causing flash, or waste material.

With the continuous injection machine only the quantities of plastics or rubbers needed are injected into dies already clamped together, eliminating flash and saving time and materials and cutting costs of production. The ordinary "one shot" injection machine, which was an advancement over the compression type, eliminates flash waste, but is limited in the size of parts it can produce. With the new Chrysler-



One of the new continuous molding machines producing link bushings for shock absorbers. The inventor, Walter P. Cousino, left, is removing links from the die

developed machine, producers are able to inject plastics or rubbers in a continuous stream as long as there is mold area to be filled. Different dies for different sizes of products can be used with the same continuous injection head.

The continuous injector consists of a simple hopper holding plastics or rubber. The material is fed to a heating cylinder where a special churning apparatus keeps it evenly mixed. The putty-like substance is then shot under screw pressures up to 22,000 pounds per square inch through a nozzle clamped to an opening where the die plates join. When the material has filled every tiny crevice in the mold, or series of molds, the back-pressure automatically shuts off the feeder.

When the machine automatically shuts off the flow of plastics or rubbers the worm screw reverses itself, keeping the material remaining in the heating and feeding chambers pliable and ready for the next injection.

Because of the uniform feed, and even mixture of materials, the curing time required by the new machine, compared to similar materials and other types of machines, has been cut by approximately 93 percent, besides the complete elimination of waste. Where multiple molds are used the tiny canals through which the putty-like materials pass from one cavity to another produce excess webbing which is easily trimmed away without impairing the finished products.

HEAT EXCHANGERS

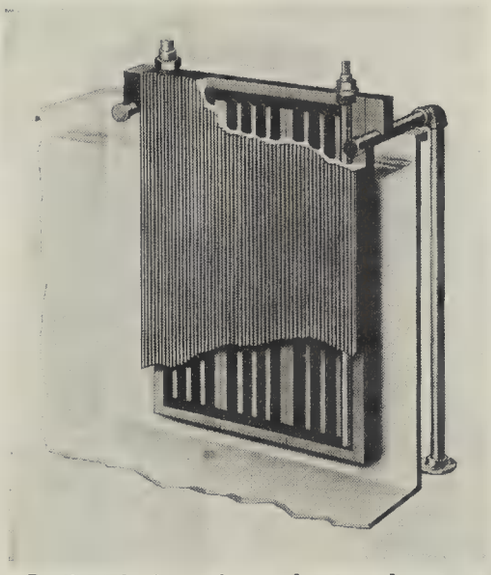
Resist Chemical Action and Temperature Changes

MADE of "Karbate" chemically inert graphite materials, a new type of heat exchanger has been perfected for use in chemical and process industries by National Carbon Company, Inc. Designed specifically for chemical applications, the corrosion resistant "Karbate" heat exchangers possess high heat transfer values and are resistant to practically all acids, alkalis, and solvents. They are unaffected by acute thermal shock and may be used freely in intermittent operations, or in alternately hot and cold chemical baths.

Of plate type, the heat exchangers employ the principle of extended, or corrugated, surface to attain maximum heat transfer area within small overall size. The compactness of the exchangers increases their inherent mechanical strength. At the same time, it reduces the tank space required for the heaters, further minimizing the hazard of mechanical shock during process operations. The exchanger is a four-inch thick plate with a number of internal 1½-inch diameter communicating channels for steam or cooling medium.

Production of the heat exchanger units is standardized in four design groups, incorporating both parallel and series flow channels, thus making possible different combinations to meet the widest range of heating and cooling requirements. The heaters may be installed in sections, depending upon tank capacity or solution temperatures required, and are suitable for nearly all tank sizes or shapes.

A number of the heat exchangers have been in use in various processes for a year or more and afford sufficient service data for comparative purposes. Such heaters, 4 by 10 by 48 inches in size, operating on 25 pounds of steam and maintaining tank temperatures of



Sectioned view of new heat exchanger

180 to 190 degrees, Fahrenheit, have been in service in tanks containing approximately 10 percent nitric acid and 3 percent hydrofluoric acid. There has been no visible sign of deterioration in these units in the year or more of their operation. In the same application, no metal heat exchanger has been found that would stand up for more than a few days.

In other types of corrosive chemical operations, the "Karbate" corrugated plate heaters have greatly increased heating efficiency and reduced process costs through longer service and through eliminating maintenance costs.

TELEVISION PROJECTION

Uses Special Lens And Mirror System

REFLECTIVE optical systems for television receivers employing special types of mirrors and lenses, according to a paper by Ioury G. Maloff and David W. Epstein of the Radio Corporation of America, are now being used to pick up images from the face of the cathode-ray receiving tube and project them on a screen suited in size to the requirements of the room or auditorium in which the images are to be viewed.

RCA systems for projection of television images, the authors of the paper stated, consist of a spherical front surface mirror and an aspherical lens. The non-technical reader may visualize the mirror as a shallow bowl, while the aspherical lens is flat on one side, with the opposite surface rising slightly at the center and at the edges, but depressed in the intermediate area. The surface contour of the lens renders it optically positive in the center with a gradual change to negative in the outer portions.

The gain in illumination on the viewing screen obtained with these new systems is about six or seven to one when compared with a conventional $f/2$ lens, it was revealed, and the quality of the images obtained is comparable with images produced by conventional projection lenses.

Because of more nearly perfect diffusion of the light emitted by the fluorescent face of a cathode-ray tube as compared to light from an intense source such as is used in motion-picture projection, the paper pointed out the efficiency of the conventional motion-picture projection lens is extremely low when such a lens is used to project a cathode-ray tube image on a viewing screen. Any increase in the brightness of the image on the face of the tube could be obtained only at great cost. Attention was centered therefore, on the problem of providing a manifold increase in the percentage of light that could be delivered to the screen.

"It has been known for a long time," the paper continued, "that aspherical surfaces in combination with spherical or aspherical mirrors may be arranged into optical systems of high aperture and high definition. Astronomers have made use of this principle, but high costs and difficulties in constructing such systems have prevented their general use.

"Since the principle had been developed only for the infinite throw used in astronomy, much painstaking study and work was required to adapt it to short-throw projection.

"Aside from this necessary adaptation of the principle, a major problem was the high cost of the aspherical correcting lens. Astronomers produced them only by tedious, step-by-step methods. The apparent solution was that of molding the lenses from a suitable transparent material.

"After such a material was found there remained the problem of making molding surfaces of metal in shapes of the negative replicas of aspherical lenses and obtaining optical finishes of



Removing from its mold one of the plastic lenses used for projecting brighter, larger television images

e metal surfaces, but this was ac-
mplished."

In one type of receiving unit de-
ribed in the paper, the projection
stem is mounted near the floor of the
binet, with its axis vertical, projecting
e image straight up and on a flat
irror inclined at 45 degrees to the in-
ming beam of light. The mirror
rows the image on a translucent
reen which is built into the cabinet.
ıch an arrangement presents the ad-
ntages of compactness and a cabinet
relatively small depth which can be
yled along the familiar lines of a
dio console.

Because of their great light-gathering
wer, the paper stated, other types of
flective optical systems, built for in-
ite rather than finite throw, find very
eful application in television pick-up
meras under conditions of low illu-
ination, such as during the last min-
es of a football game or in direct
ck-up from a theater stage.

IBBER TANKS

veloped for Fuel

ansportation

ORTABLE synthetic rubber tanks are
w being extensively used in combat
eas for both transportation and stor-
e of gasoline, oil, and aromatic fuels,
insure an adequate supply of these
tal materials at all times.

Developed by United States Rubber
mpany, these huge collapsible tanks
n be set up or taken down very
ickly. Advantages of the synthetic
bber fuel tanks for overseas use are
at they are collapsible and can be
pped in small space. They are light
weight, easily camouflaged in the
ld, and can be quickly set up or
ocked down for transportation to a
w location by a very small crew. Be-
re their use, steel tanks were needed
r storing or transporting gasoline.

Tanks for transporting fuel are made
ith 750 gallon capacity, carried on a
andard 2½-ton truck, and with 2700
llon capacity, three of which are
rried on one railroad flat car.

Storage tanks, used for advance com-
t or reserve supply back of the lines,
ill hold either 1000 gallons or 3000
llons of gasoline.

The collapsible fuel tanks are made of
ildew-proofed fabric coated with syn-
etic rubber. Tanks can be repaired
the field as easily and speedily as can
tire's inner tube.

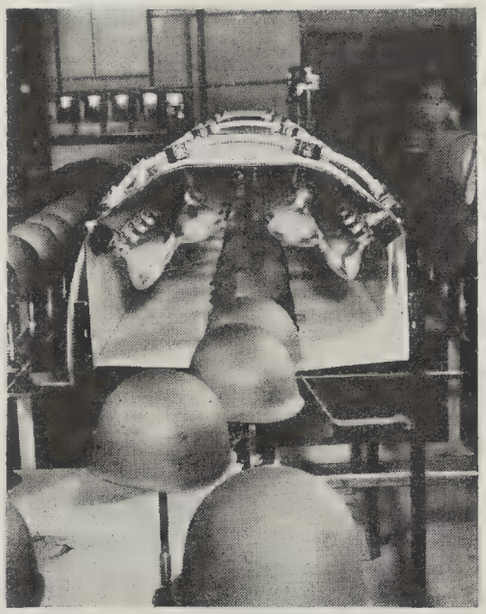
FRA-RED LAMPS

n be Applied to

any and Varied Uses

EW post-war heat sources, speeding
eace-time drying jobs in the home and
dustry and providing a flexible sup-
ement to regular space heating equip-
ent, will be developed from infra-red
mps, according to James D. Hall,
estinghouse Lamp Division engineer.
"Lamps operating on the same prin-
ple as those which now are swiftly
oking' paint on tanks, jeeps, helmet
ers, and other war material," Mr. Hall
ys "can be used to dry everything in
the home from fingernail polish to
freshly bathed Fido. Heat lamps also
will be popular for chasing the chill out
of the house during late spring and
early autumn."

As comfort heaters, Mr. Hall forecasts,
radiant heat lamps screwed into regular
lighting circuits and clamped on the
reading-lamp fixture will be beamed to
keep the reader's neck and shoulders
comfortable. Similar lamps, spotted
around the house, could protect tender
plants from the cold, speed up the dry-
ing of hair and laundry indoors, and



Drying time for Micarta helmet liners is radically reduced by passing them under a bank of infra-red lamps

perform other household drying and
spot-warming chores.

Up to now, heat lamps have been ap-
plied mostly to industry for war-time
drying jobs. A vast indicated expansion
in industrial uses, particularly in auto-
mobile plants, textile mills, and food
dehydration plants, offers what the
specialist described as the "brightest
prospects" immediately after the war.

Banks of infra-red lamps will be on
every post-war automobile assembly
line, the engineer forecasts. From five
to six minutes will be required to
whisk a thoroughly dried automobile
off the paint rack, instead of the 50
minutes required by the customary
drying process in pre-war days. In
woolen mills, lamps heat the cloth to
high temperatures so that unwanted
particles of wood, burrs, and other
foreign material in the finished product
are reduced to carbon which can be
easily shaken free. In food dehydration,
infra-red reflector lamps can dry food
in five to 30 minutes, as compared with
15 to 30 hours previously required.

Listing some peace-time industrial in-
fra-red applications which already are
in operation, Mr. Hall says the man-
made radiant heat is quickly and ef-
ficiently drying foundry molds in place
of drying by kerosene torch; fusing
label paint onto glass bottles; baking
insulating varnish on electrical equip-
ment and paint on electrical trans-
former tank covers; drying glue on
paper envelopes; processing burlap used
for sandbags, and drying sample
swatches of cloth pasted on cardboard.

Typical of the war production contri-



Infra-red lamps, placed under desk, keep the office worker comfortable

bution of radiant heat lamps is their
record in drying the paint on tanks, Mr.
Hall says. Radiant heat lamp rays,
beamed from the sides of a drying tun-
nel in one of the nation's giant tank
arsenals, complete the drying of paint
on tanks in four minutes instead of the
24 hours required previously. In the
manufacture of plastic helmet liners
for the Army, infra-red lamps have
speeded the drying process from an
estimated 15 minutes by the oven-dry-
ing method to a new low of 95 seconds.
The oven process required a tunnel-
shaped unit 225 feet long; the infra-red
dryer is 19 feet long.

Still another peace-time possibility for
the lamp is the assistance they will give
the motorist in winter. One bus com-
pany, the lamp specialist relates, "no
longer has trouble starting its vehicles
on cold mornings. Infra-red lamps
turned on under the hood of a bus an
hour or so before the driver reports for
work, bring the engine to spring-like
temperatures."

TREE OF LIFE

Yields Industrial

Materials in Brazil

BRAZIL has a tree which produces the
most important vegetable wax in the
world, flourishes in drought when other
vegetation withers, yields food, fruit,
medicine, and materials for building
paper manufacture and other useful
arts, according to *Chemical and Engi-
neering News.*

The tree is the carnauba wax palm,
known as the "Tree of Life." It has
defied not only the greatest scientists
to produce it synthetically, but also
other nations to grow it successfully.

"When everything else shrivels and
seems to die, the carnauba palm reaches
its greatest productivity in wax," re-
ports Dr. Nelson S. Knaggs of the
Hilton-Davis Chemical Company of
Cincinnati.

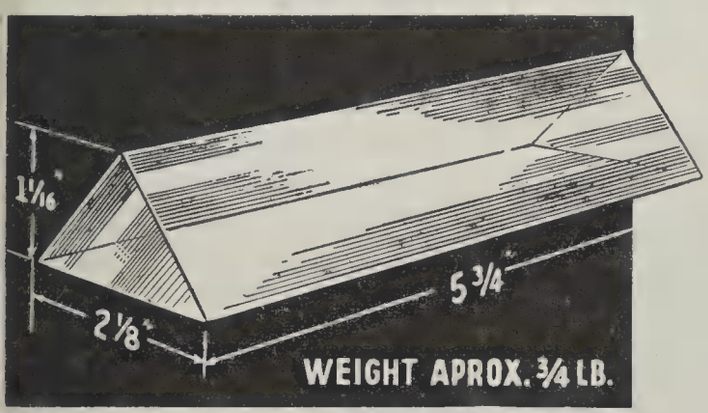
"Cattle can live on the shoots of the
young carnauba palms which emerge
from the baked earth. The tender
hearts of the palm become a green
vegetable or salad. The tree bears long
clusters of edible fruit not unlike a

SENSATIONAL WAR BARGAINS in LENSES & PRISMS

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections which We Guarantee Will Not Interfere with their Use. All Lenses neatly packed and marked for Diameter and Focal Length.

OUR POLICY on WAR SURPLUS

1. We are cooperating to move surpluses while the war is on.
2. Our customers receive full benefits of all savings effected through our purchases of war supplies. We do not hold merchandise for high present or future prices.
3. We are making a special effort to bring our items to the attention of all Schools, Colleges, Amateurs.



TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

You can use these Prisms to make Periscopes to see over the heads of crowds, fish under water, high or low gauges, inspection of machinery without climbing, for examination of hot metals without danger to eye or camera, etc. Also excellent for experiments, class-room demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachment, photometer cube, range finder, etc. And here's an excellent, unique gift idea. For 5¢ we supply 100 gold letters with which you can turn any of these Silvered Prisms into a desk name plate in 5 minutes of easy work.

Normally, these Prisms would retail from about $24 to $30 each.

Stock #3004-S . . . SILVERED TANK PRISM — Price $2.00 each Postpaid. Free Booklet on Prisms incl.

Stock #3005-S . . . PLAIN TANK PRISM — Price $2.00 each Postpaid. This is excellent for projecting all the colors of the spectrum — a beautiful sight. Free Booklet on Prisms incl. FOUR TANK PRISMS — Special $7.00 Postpaid . . . This is the most sensational bargain we have ever been able to offer.

ATTENTION HIGH SCHOOLS AND COLLEGES!

Scrap Optical Glass for educational purposes to show various stages of manufacturing from blank to finished Lens and Prism.

Stock #6001-S . . . for schools . . . 5 lbs. of assorted Binocular Lenses and Prisms in various stages of completion — $5.00 Postpaid.

Stock #6002-S . . . Educational Set for Individuals . . . consisting of 1 Porro Binocular Prism Blank and 1 finished Porro Prism — Price 25¢ Postpaid.

REDUCING LENS SET #1004-S . . . . . $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 70-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.

The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

50-PAGE ILLUSTRATED IDEA BOOKLET . . . . $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

PORRO ABBE PRISMS #3006-S . . . . 25¢ each Postpaid
Size 9 mm. by 17 mm. . . . another war bargain. Normal prices would be 10 to 20 times above quotation.

WAR BARGAINS IN LENSES USED IN NAVY'S 7 POWER BINOCULARS

KELLNER EYE-PIECE LENSES with F.L of 27.5 mms. Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. Unedged Lenses about 2 mms. larger than edged ones. These are excellent for all sorts of telescopes.

Stock #6060-S — Uncemented and Unedged — 75¢ Postpaid
Stock #6061-S — Uncemented but Edged — $1.25 Postpaid
ACHROMATIC OBJECTIVE LENSES with F.L. of 193 mms. Have wider diameter than those used Army's 7 power binocular. Excellent for telescopes. Diameter of edged lenses are about 52 mms. Unedged about 53 to 56 mms.

Stock #6063-S — Unedged and Uncemented — Price 75¢
Stock #6064-S — Edged and Uncemented — Price $1.75
COMPLETE SET OF LENSES AS ABOVE AND THE PRISMS TO MAKE A MONOCULAR (TELESCOPE)
Stock #5100-S . . . Monocular Set . . . $5.00 Postpaid

LOW POWER MICROSCOPE LENS SET — (May also be used to make Telescope Eye-Piece) Perfect Lenses, one with diameter of 9 mms., F.L. of 20 mms., and one with diameter of 14 mms. and F.L. of 39 mms.

Stock #1003-S — Price 70¢ — includes free copy of our Microscope Booklet.

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date. The seed is crushed and a cooking oil is extracted. The shell around the nut is roasted and a coffee-like beverage is brewed.

"The pith of the tree contains a high starch content, and a food similar to farina is made. The roots yield an extract and medicine for illness. The wood is burned and the ashes yield an alkali for home soap making. The wood of the tree is extremely hard and is impervious to insects and sea water. It is used in building the frames of native homes. The fronds of the palm are used to thatch their houses.

"Most of the natives in the carnauba sections sleep in hammocks, and it is said that 80 percent of the people sleep in hammocks woven from carnauba frond fibers. Their homes are swept with brooms made from the fanlike fronds and candles made from the wax furnish light at night. Tons of fronds which have been discarded after the wax has been removed may play an important part in the new Brazil, for a high-grade paper has been made from it."

ASSEMBLY-LINE FREEZER

Rapidly Shrinks Parts and Dispenses Them as Needed

A COMBINATION refrigerating machine and dispenser used in the aircraft building at the Ford Motor Company has cut in half the time necessary for a single assembly operation which depends on shrinking of parts by the liquid oxygen method.

Tappet guide inserts, 36 of which are used on each of the 2000-horsepower Pratt and Whitney engines manufactured, are shrunk by reducing their temperatures to 300 degrees below zero. The new type freezer and dispenser makes this possible on an assembly-line basis.

Outwardly the dispenser resembles a soft drink vending machine. There are eight openings to accommodate various size guides. To obtain a shrunk part, the operator inserts one from stock and presses a button. A chilled part drops into a rubber receptacle at hand level. If desired, a shrunken part may be obtained without inserting a warm one.



A tappet guide insert at room temperature is pushed into the freezing dispenser. Cold-shrunk inserts are delivered, as needed, at the bottom

The parts never come in direct contact with the liquid oxygen. They are chilled by their slow passage through tubes suspended in a tank of liquid oxygen.

At normal temperatures the valve tappet guides are from two to three thousandths of an inch over-size. After emerging from the refrigerator they drop into prepared holes with ample clearance and expand as they warm. The resultant fit is nearly as firm as a weld.

The advantage of shrinking a part to size lies in the fact that no metal is removed or burnished by forcing it into position. Normal machining leaves tool marks around a part in a position radial to the center. When these microscopic grooves expand, from the center out, they fill in the high spots and valleys of a prepared hole and create a much better seal.

Before the dispenser was developed, tappet guides were placed in a container which was immersed in liquid oxygen. The machine was built to Ford specifications by the Linde Air Products Company.

SEALING ZIPPER

Makes Water- and Air-Proof Closure

DEVELOPMENT of a unique rubber construction applied to metal slide fasteners which makes them completely water-proof and prevents escape of air or gasses was recently announced by The B. F. Goodrich Company.

The Pressure Sealing Zipper is constructed with over-lapping rubber lips which have such initial pressures built into them that they assure a perfect seal against any pressure which the structural strength of the slide fastener will withstand.

The lips are placed on either side of the article to be sealed, depending on where the pressure is exerted. Used on the outside they make the article water-proof and prevent the entrance of air or gasses. Used on the inside they prevent the escape of air, gasses, or liquids held in the vessel.

Three such Zipper styles are being manufactured, two being of the non-separating type, the first sealing along its entire length but open at the top, the second sealing along its entire length and at both ends. In the first, which is used in such applications as exposure suits, the slider is operated from either side; in the second, originally developed as a closure for pressure vessels, it is operated from the side opposite the sealing lips.

The third construction is of the separating type, which seals along the entire length but not at the ends, with the slider operating from either side.

The new rubber Pressure Sealing Zipper can be applied to metal, fabric, or sheet rubber, provided that sufficient clearance is allowed for operation of the fastener. Installation can be accomplished either by stitching or cementing, depending on the use.

The pressure seals are effective in a wide temperature range, not cracking when bent at — 70 degrees, Fahrenheit, nor becoming soft at 150 degrees, Fahrenheit. Weathering and aging characteristics are reported to be excellent.



Unzipping one of the self-sealing water- and air-tight slide fasteners

One of the great advantages of the sealing lip construction is that it conforms to changes in position of the sealing wall, withstanding stresses caused by these movements.

Among the war-time uses for the Pressure Sealing Zipper, according to the company, are as closures for life saving suits or divers suits, which need to be perfectly water-proof. Use of the Pressure Sealing Zipper makes these much easier to put on or take off.

Many uses of the new development are present in the airplane industry, the company says, including application on both high and low pressure ducts, where sections may be effectively joined with a Pressure Sealing Zipper, on doorways and handholes, where there are pressure differentials, and on bail-out kits and instrument cases.

Other potential uses which the company sees are as openings for tent flaps, where the arrangement makes the flap water-proof, as covers for hatches and other places on shipboard, and as seals for all types of emergency equipment.

SWEET-POTATO ALCOHOL

Seen As a Possible Solution to a Problem

THE FOOD program, molasses transportation difficulties, and tremendous alcohol requirements have focused attention on new raw materials for alcohol production. The subject promises to be of continuing interest in the post-war period if the industrial alcohol requirements remain above 300,000,000 gallons. There will be insufficient molasses to provide for fermentation alcohol, and corn or wheat prices may be prohibitive for industrial alcohol production

Drs. Jump, Stark, and Zarow of the Seagram Research Department, reported at a recent American Chemical

Society meeting on the use of dehydrated sweet potatoes as a raw material. Their laboratory and plant studies indicate that the L-4-5 variety of "non-edible" sweet potatoes are superior to the Puerto Rico variety. The laboratory yields compared with corn were respectively 3.2, 3.0, and 2.7 wine gallons at 190° proof per 56 pound bushel.

A commercial trial at one of the Seagram plants resulted in a yield of 2.8 wine gallons per bushel of L-4-5 potatoes; the yield from the Puerto Rican variety was lower. This plant fermentation yield problem is under current laboratory investigation, and appears to be susceptible of solution.

Dehydrated sweet potatoes offer the advantages of storage to provide a year-'round supply, and processing with equipment similar in design to conventional grain alcohol plant equipment.

The authors concluded their paper with the observation that the yield of alcohol from sweet potatoes in terms of acres of land is much higher than can be obtained from grain and closely comparable to sugar cane. The difficulties standing in the way of immediate use of this raw material are the small acreage now in cultivation, the necessity for simplified planting procedures, and mechanization of the harvesting operations. A Seagram Fellowship has been established at Louisiana State University, where the L-4-5 sweet potato was developed, to improve planting and harvesting procedures.

On the other hand, sweet potatoes may be grown throughout most of the South and under efficient farm management high yields per acre may be expected to bring the raw material cost in line with molasses. Thus sweet potatoes offer another possibility for agricultural and industrial expansion of the South by virtue of their value as a raw material for alcohol.

INDUSTRIAL DEVELOPMENT

Held to be Curbed by Present Tax System

EVEN after the pent-up demands for merchandise growing out of war shortages have been met, prosperity can be maintained in post-war America on the basis of new products and a higher standard of living than ever before, according to Larry E. Gubb, chairman of the board of directors of Philco Corporation.

"Actually years of research and development have been crowded into the past 32 months since the war began," Mr. Gubb said. "The stern necessities of war have been a great stimulus to research and technical progress on the part of our scientists. This war, which is being fought on both sides with the very newest technical weapons, has carried us along the road to new scientific developments at breakneck speed. The world of 1940 has already become obsolete.

"Our nation will emerge from this war with a capacity for producing raw materials and manufactured goods of unprecedented quality and workmanship on a scale never dreamed of four years ago. Great new industries, such as television, frozen foods, private and commercial aviation, and many others, are on the horizon awaiting development and offering tremendous employment opportunities.

"But before we Americans are going to participate in the advance of our scientists, there must be created the desire to get in and build this economy. We must recreate the incentive system that encourages enterprise and stimulates new undertakings. That is the way jobs are made.

"The figures show that in our country it takes about $5000 of invested capital to create a new job. Nothing could do more to make for a high level of employment and great prosperity after the war than the encouragement of 'risk capital.' If all capital is going to seek 100 percent safety, there can never be any progress. All you get is stagnation.

"But if capital is to be expected to embark in new ventures, there has to be some incentive held out to it; there has to be a reward for risk-taking, or people with capital cannot afford to do otherwise than hold it idle.

"These incentives are entirely lacking under our present tax system. Under today's conditions, there could be no such things as the building of our great railroad systems; the automobile industry could never get started and grow to maturity, for the simple reason that if a failure ensued, the burden would have to be borne in



How to Predict the Winners in Tomorrow's Production Ra

This metallographer is using Bausch & Lomb Metallographic Equipment, a microscope and photomicrographic apparatus designed especially for the study of the fine structure of metals under high magnification. Before him each day pass the enlarged, prophetic pictures of tomorrow's industrial miracles —recorded photographically, if need be, for tomorrow's use.

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large part by those who furnished the capital, while if they were successful, an extremely high percentage of the profits would be drawn off in corporate income and excess profits taxes and, insofar as earnings were paid out, in personal income taxes. In other words, as things stand today, the tax collector says, 'Heads I win; tails you lose.' "

NYLON APPLICATIONS

Will Spread Into Many Post-War Fields

MILITARY applications of nylon developed during the war suggest possible uses for this versatile synthetic yarn in civilian fabrics, according to George J. Groh of the Nylon Division of E. I. du Pont de Nemours and Company. Mr. Groh, in charge of nylon fabric development, says that, for example, the weaving of nylon insect netting has given the textile industry experience in handling the yarn, which might be utilized later on in the weaving of similar fabrics for many uses.

"A 30-denier nylon flare (parachute) fabric is not far in construction from a nylon sheer," he points out, adding that "with some minor changes in weaving and a few more turns in the yarn, a fabric might be developed which should have a large number of practical uses."

The nylon fabric which is now going into the human escape parachute might, by being built up slightly in construction, suggest a sleeve lining, Mr. Groh adds.

Development of woven nylon fabrics was undertaken before the war in a limited way and all work of this kind was stopped as soon as nylon was needed for military purposes. The early studies were carried far enough in the development of fabrics for underwear, slips, panties, gowns, and foundation garments to indicate that nylon contributed a great deal toward lessening the weight of garments, he says, and its advantages in easy washing and quick drying were found particularly valuable.

Experimental work before the war also indicated that properly constructed fabrics of nylon could be permanently "set" to minimize wrinkling and that they might possess advantages in washability. This work gave definite indications that good nylon neckwear could be manufactured, that nylon in velvets and other pile fabrics could be made crush-proof, that the curtain stretcher as a result might "become a thing of the past," and that permanent ruffles and pleats might be "set" so as to be unaffected by cleaning and even washing.

POWER CONCENTRATIONS

Are Crux of Electronic Heating Processes

IMPROVEMENTS in the heat treating of metal products made possible by the use of electronic power concentrations up to 20,000 kilowatts per cubic inch are described by Dr. Wesley M. Roberds, development engineer of the RCA Victor Division, Radio Corporation of America. Power concentrations of this order, Dr. Roberds explains, have advantages of product quality improvements growing out of closer control and more uniform effects. Additional advantages include increased production resulting from savings in process time, greater heating efficiency, and greater convenience.

"When intense heat concentrations are mentioned," he says, "one immediately thinks of the oxy-acetylene flame or the electric arc. In the case of the torch, the transfer efficiency from source to work is extremely low, so that heating equivalent to that produced by an electrical power concentration in the work of five kilowatts per square inch is about the maximum attainable at present. In electronic induction heating it is not difficult to put 100 kilowatts into a square inch of surface area with an overall efficiency of 50 percent.

"With the electric arc, the power concentrations may be comparable to those obtained in electronic induction heating, but the intensity of the arc has a much lower range of control. With a 100-kilowatt electronic power generator, the surface of a two-inch steel bar can be brought to the melting point in half a second, or the power can be reduced until it will require five seconds to solder a small can.

"The ability to create very high power concentrations is especially advantageous in processes where it is desirable to confine the heating to a small, sharply defined volume. For example, in such operations as case-hardening, welding, brazing, or soldering, it is desired to heat only a thin shell or a narrow strip on the work, while the other parts are to remain relatively cool. This effect may be achieved by applying the necessary energy at high power levels for very short times, thus minimizing the conduction of heat and creating high temperatures only in those regions were heating is desired.

"Because the current penetration into the work is small, the application of 100 kilowatts per square inch may result in a power concentration in volume of 20,000 kilowatts per cubic inch. This concentration of energy beneath an inductor makes it possible to heat a highly localized area on a piece of work."

Although power concentrations attainable in dielectric heating of electric insulators such as wood and plastics are much lower than those used for induction heating of metals, Dr. Roberds says, they are nevertheless up to 1000 times as great as can be obtained by heat conduction into the work. Practical power concentrations in electronic dielectric heating range from 10 watts per cubic inch at a frequency of 10 megacycles, used for gluing thick wood sections, to 20,000 watts per cubic inch at 200 megacycles, used to seal thin plastics films.

CAM CUTTER

Performs Special Operation In Routine Manner

DESIGNED to cut two irregular curved tracks of minute dimensions on the inside of a thumb-sized metal barrel, a special cam-cutting machine has proved highly successful in operation in a plant of Fairchild Camera and Instrument Corporation.

Believed by its designer, Edward Lay, of the Fairchild company, to be the only machine which cuts inside tracks on a barrel cam, it grew from urgent military needs. Assisted by Theodore Fraser, a Fairchild tool designer, Lay planned an assembly including a carriage, chuck, and two master cams in one unit; stationary followers in the second; and a third cutter head unit.

The two master cams govern the track cutting, giving it a forward motion. In one revolution of the master cam the barrel turns three times, and a track is milled on its smooth surface. This revolving action is attained by one worm and two worm gears. The result is like a bullet in flight, which spins as it shoots forward. Weights keep the master cams in constant contact with stationary followers.

An operator can master the fundamentals of the special cam-cutting



The operator is holding one of the barrels to be milled in the cam cutter

machine in two days. Placing a metal sleeve on the carriage, he pushes the cutter into place, then turns on the power unit, and with it a flow of kerosene to lubricate the action and clean stray chips from the cutter. As the cutter spins through the solid metal, the operator steadily turns the carriage's handle, moving the cam slowly along while the cutter bites its first track. Repeating the operation, a second track is cut. Though the carriage handle was formerly turned by power, it was found easier to detect manually any "bugs" in the operation.

Though the machine was originally designed to fulfill the need for a particular type of barrel cam, it is equally adaptable to the manufacture of other types. Lay believes it will aid many designers who have omitted vital parts of their machines simply because they lacked a practical way to cut barrel cams.

SOUND-CONDITIONING

Involves Control of Waves to Reduce Undesirable Noises

Add to the possibilities of post-war living one more—"sound-conditioning." New types of plaster have been developed, according to the Gypsum Association, which make it possible to have every room "conditioned" to sounds as they can now be conditioned to temperatures.

The industry expects this new development to make rapid strides, and soon to be incorporated in the plans for many institutions, office buildings, apartment buildings, and individual homes. Reported to be less expensive than other materials for the same purpose, it will have an appeal for the great mass of new home builders, the Association says.

Sound-conditioning and sound-proofing are distinctly different, the Gypsum Association points out.

"A room is sound-proof if sounds originating in it cannot be heard outside the room, and vice versa. Sound-conditioning has to do with the control of sound reverberations and the curtailment of echoes—the absorption of sound waves after the action that created them has ceased. Sound-conditioning is the control of sound waves to reduce undesirable noises."

Greatly advanced over previous materials of its type, the new gypsum acoustical plaster is inexpensive. It is very porous, the air passages "blotting up" the sound. In most cases its use on ceilings alone is sufficient.

THE WAY TO WEIGH

There's More to It Than Meets the Eye

If you had several objects to be weighed on a refined balance, how would you go about weighing them? "Well," remarks your hard-headed friend who is suspicious of too much theory, "I'd just plain go ahead and weigh them, that's all. What else could I do?"

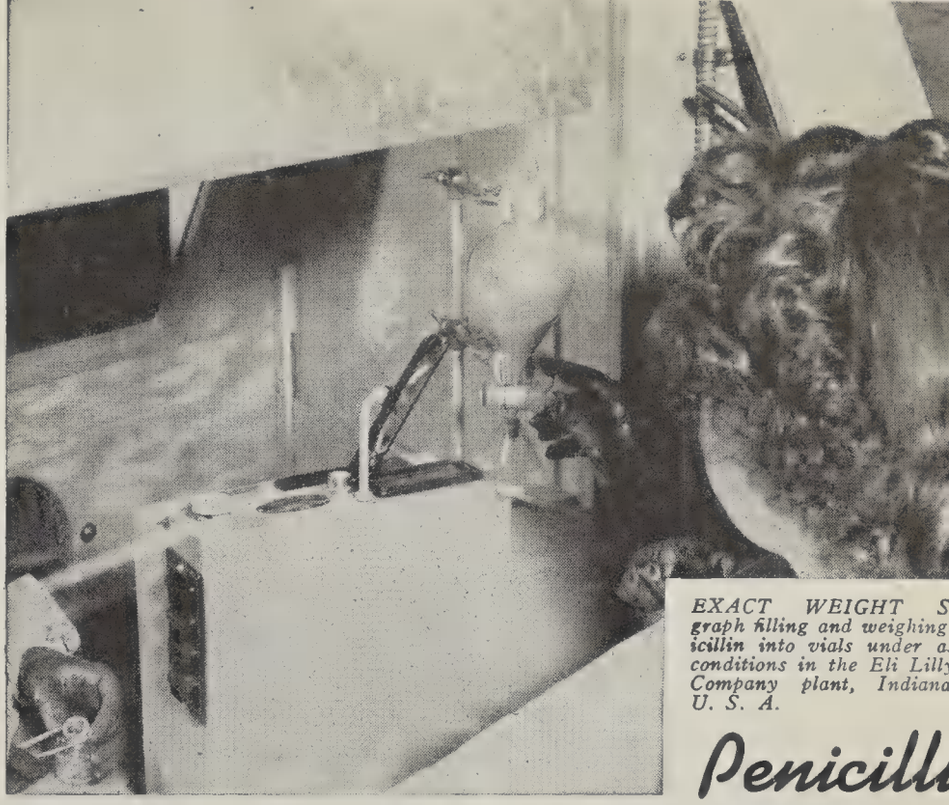
That could be done and wouldn't be wrong but there are even better ways. When you begin looking into the subject, you find, perhaps, some things you hadn't thought of before. At a recent meeting of the Institute of Mathematical Statistics, Professor Harold Hotelling of Columbia University explained what applied mathematics has to say about some of these practical considerations of which relatively few readers are aware.

"For example," Professor Hotelling pointed out, "if two objects are to be weighed on a balance which is known to be correct, they should be weighed together in one pan, and also weighed with one of the objects in each pan. From the sum and difference thus obtained, the separate weights can be determined with greater accuracy than as if the objects were weighed separately

"If the weighing is to be repeat several times so as to get greater a curacy in the averages, only half many weighings are required in t combined operation as for separa weighings giving the same final a curacy," he said.

Greater economies of effort are po sible with larger numbers of objec to be weighed, Dr. Hotelling reporte If seven objects are to be weighed on scale which must itself be correct for bias, eight weighings are necessa in all.

For various other numbers of objec Dr. Hotelling described efficient weig ing plans, for various other situatio and numbers of objects to be weighe deriving them from the statistical theo of the design of experiments by mea of the mathematical principle of orth



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gonality. He pointed out that this statistical theory has been used widely by agricultural and other biological experimenters to improve the efficiency of their work, and has also entered into census operations and other economic and social investigations involving stratified sampling in this country, in England, and in India.

However, physicists and chemists have on the whole been ignorant of the new statistical developments and consequently have been put to unnecessary work, or else loss of accuracy, in many of their experiments, he declared.

John Mandel, a chemist of New York City, discussed Dr. Hotelling's paper from the standpoint of practical laboratory work, and suggested that an analytical laboratory should have some simple equipment, including standard cups of predetermined weight, to facilitate the application of the new methods. It was stated that, following Dr. Hotelling's suggestion, some of the new methods are already in use at the United States Customs Laboratory in Boston.

OIL TESTING

Eliminates Necessity

Of Using Engine

PERFECTION of a new method of testing lubricating oils will help to open the way for the lubrication of the high-speed, high-compression motors which post-war developments will put on the market.

The new testing method was described by Dr. E. C. Hughes, director, Chemical Research Department, The Standard Oil Company (Ohio), at a recent meeting of the American Chemical Society.

Under ordinary procedure, lubricating oils must be given at least a 36-hour test in an ordinary automobile motor. This limits drastically the testing which can be done.

The causes of the deterioration of oil in an engine were disclosed to be a combination of heat, air, and certain catalysts found in engines.

Under the new method the oil is examined in a specially designed test tube. The tube is held in an aluminum block in which the temperature is controlled to correspond to the temperatures in the motor. Within the test tube are the metals and other catalytic materials found in a motor in the same proportion as they are in motor construction. The oil is placed in the tube and a certain rate of air is passed through the oil. A unique arrangement enables the air to agitate the oil and keep solids in suspension.

Though the test takes 36 hours, many of them can be made at the same time. The results parallel those revealed by the use of an engine.

Modern lubricating oil is a laboratory product. The natural oil is used as a base and other chemical materials are added to prevent corrosion, sludge, thickening, the formation of "varnish," and the formation of carbon.

"With this in mind," said Dr. Hughes, "the more tests we can conduct, the more rapidly we can discard unsatisfactory products and perfect those of superior quality. Within the past two years we have tested well over 600 combinations in the laboratory—many more than we could have done had we used the regular automobile motor."

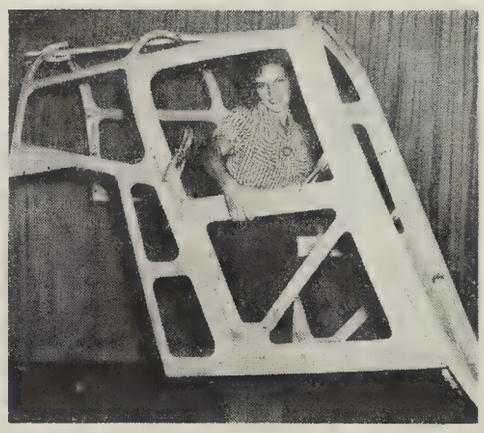
HELICOPTER CABINS

Will Incorporate New

Plastics Structural Material

PLASTICS are being used for the cabin structures of the new helicopter, R-6, which may help speed war wounded from inaccessible combat areas and may soon be servicing military outposts with needed supplies.

The plastics material, developed and produced by the United States Rubber



Light-weight helicopter cabin frame

Company, was chosen for the cabin structures because of its light weight—only half that of aluminum of similar thickness—together with its great tensile strength, rigidity, and ability to withstand strains and excessive vibration. It met specifications of the A.A.F. Materiel Command at Wright Field for this new structural use after it was put to many rigid tests.

Made of Fiberglas, laminated and reinforced with thermo-setting resin, the composite material is a non-conductor of electricity and is not affected by gasoline, oils, acids, most alkalis, alcohol, or fungus growth. After a blow, it returns to its normal position with no permanent distortion or denting. Another feature is that it retains all of its properties in the sub-zero temperatures of the Arctic as well as in the excessive heat of the tropics.

As far as is known, this is the first use of laminated plastics on a production basis in this type of construction. Its success probably will open the way for many post-war applications of this plastics material. It is now extensively used to support bullet-sealing fuel cells in all types of combat planes.

PAINT

An Important Part of

The Housing Problem

IT IS of the utmost importance to get the word around that America cannot be rebuilt over night, believes the Post-War Planning Committee of the National Paint, Varnish, and Lacquer Association.

"We couldn't all have new homes at once—even if we had the money to pay for them and new construction started up at full speed immediately post-war," points out the latest edition of the committee's post-war planning publication, *Looking Toward Tomorrow.*

"Our present homes will be needed for a long time to come," it continues. "Therefore, for those who live in the 38 million dwelling units of the nation already in existence—which now average 25 years of age—and for the half million new families formed each year, we must make our present structures last."

Furthermore, the bulletin points out, the paint industry can help the owners of down-at-the-heel properties who wish to buy new homes. Much higher prices for their present properties can be realized if they are put in the pink of paint condition, both inside and out, before offering them for sale, it states. In this way property owners can realize a larger sum for investment in a new home when it is possible to obtain one.

Still another reason for the maintenance of existing dwellings is reflected in the need for housing lower income groups. As new homes are built and occupied, the older, moved-out-of homes—if adequately maintained—can be used to house comfortably those with lower incomes who formerly lived in much worse surroundings. In time, the elimination of obsolete and unfit housing can thus be facilitated.

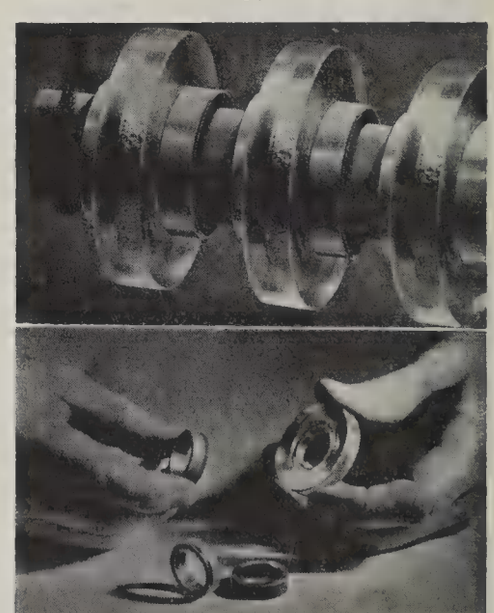
"It's tremendously important to give our nation's homes a good, rugged transfusion of paint plasma as soon as possible," the bulletin stresses, "so they will hold their own."

CARBON PLATING

Speeded by Use of

Plastics Jigs

IN A FIELD where previously-used materials were severely limited, Plexiglas masking jigs are now used exclusively in the copper plating of carbon rings by the Morganite Company, manufacturers of carbon specialties. Because of its machinability, dimensional sta-



Top: Plexiglas masking jigs. Bottom: Carbon rings, plated except for the narrow edges protected by the masks

bility, and light weight, Plexiglas has been found most successful, not only reducing rejects but also stepping up production rates. Carbon rings to be plated are inserted in grooves on either side of the Plexiglas jig rings. They are then mounted in gang fashion on a carbon rod; electrodes are attached and the entire assembly is suspended in a plating solution. The durability of these Plexiglas jigs and their resistance to the plating solution makes them highly practical.

SPECIAL PRODUCTION TOOLS

Have Limited Application to Peace-Time Manufacture

THE DEFEATS suffered by American arms in 1941 at Pearl Harbor, Guam, and the Philippines spawned a phrase that no adult American is likely to forget during his lifetime—"too little and too late." It was freely and widely interpreted to mean that our fighting men simply had too few weapons and the wrong kind of weapons to meet the enemy on even terms.

Not nearly as well appreciated was the truth that these weapons didn't exist because the precision machinery required to make them didn't exist either. Even after a long uninterrupted string of victories in Africa, Europe, and the Pacific it is difficult to grasp the direct connection between a high-speed automatic screw machine in a mid-western arms plant and a machine gun platoon entrenched in a palmetto clump on the island of Saipan.

Mass production in volume means proper tooling. But even though about 75 percent of the automotive industry's tools were converted to war production, the war products were so radically different from cars and trucks, and the need for these weapons was so great that thousands of additional tools were required—special tools, designed specifically to machine tank parts, to extrude aluminum for airplanes, to draw out slabs of metal into long cartridge cases.

These specialized tools, so vital to victory, take on a different aspect when viewed against the post-war era. About 10 percent of the special war production tools made for the automotive industry have no foreseeable peace-time use. Converting them would be prohibitively expensive, and their cost of operation would be disproportionately large after they were converted, because they were made to handle heavier metals in larger quantities than peace-time goods would call for.

Consider, for example, a 3300-ton rod extrusion press, made to handle aluminum for aircraft production. The complete installation of such a press costs $250,000 and, because of its size, six freight cars would be required to transport it from one location to another. Throughout the war, it labored faithfully on millions of pounds of aircraft aluminum, but after the war there may be no demand for its capacity.

Or, what of the huge vertical boring mills especially designed to speed tank manufacture? Weighing 112,000 pounds, and costing $49,500 each, these mills can handle an armored tank turret with ease, but in peace-time there will be no immediate need for their sinews.

Again, what of the complicated machine which drills, reams, countersinks, and mills the trigger housing of the Garand rifle? Its cutters work simultaneously from six different directions, and this one machine alone does in 58 seconds the work which it formerly required four general-purpose machines each 11 minutes to perform—an increase in productivity of 4400 percent.

Many hundreds of machine tools like these are in automotive war production, and their daily output of war goods makes up a large part of the mass of material which is giving the Allied armies ascendancy on every front. Their cost of construction and operation is part of the price of victory in war, and their proper disposal bids well to be of major importance in the over-all problem of reconversion.

To avoid having them interfere with reconversion, however, a true and realistic appraisal of their worth to the nation's economy must be made, not in terms of their cost, because that cost is part of the price of victory, but rather in terms of what they can contribute efficiently to the post-war production volume of the industry.—*Automotive War Production.*

FOOD PACKAGING

Requirements Studied for Frozen and Dehydrated Foods

TEMPERATURE is not an important factor in maintaining stored dehydrated foods at a low moisture content, but it plays an important part in maintaining moisture levels in stored frozen foods, says Dr. G. J. Hucker, food bacteriologist at the State Experiment Station at Geneva, New York. Doctor Hucker and his associates are studying the packaging and storage of processed foods under a range of temperature and humidity.

Dehydrated beets with a moisture content of 5 percent were stored unprotected under various conditions ranging from 20 to 29 percent relative humidity. They reached equilibrium

SOUTH BEND LATHES



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Nowhere is precision equipment more important than in the research work of industry. For the exacting machine work required in the development of special testing equipment and experimental models, precision lathes are indispensable. Many industrial research laboratories, such as that of a large steel plant shown above, depend on South Bend Lathes because of their unvarying precision and time-saving versatility.

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with the surrounding atmosphere in about six days in an atmosphere of 90 percent relative humidity, while it required 40 days for them to reach equilibrium in 20 percent relative humidity. With this information as a basis, the Station workers made a series of tests of protective wrappings and packages which varied in moisture transmission rates.

"Thirty-two trials of this type have been completed," says Doctor Hucker, "and results indicate that, in order to maintain a moisture level sufficiently low in dehydrated vegetables to retard spoilage by microörganisms, the protective wrap should have a moisture vapor transmission rate of less than 0.3 gram of moisture vapor per square meter if the stored foods come in contact with an atmosphere of 70 percent relative humidity or over. The results also indicate that temperature is not an important factor in the protection of stored dehydrated goods against moisture absorption."

In a similar series of experiments with wrapping materials for frozen foods where the relative humidity in cold storage lockers is relatively low, it was found that temperature is an important factor in maintaining moisture levels in stored frozen foods. Selected frozen foods were held at 10 degrees, Fahrenheit, and at minus 2, minus 5, and minus 20 degrees. Preliminary results indicate that wrappers with higher moisture vapor transmission rates may be used for frozen foods to prevent "freezer burn" than can be used in protecting dehydrated foods against moisture absorption.

TRANSPARENT LAYOUTS

Assist in Visualizing Industrial Plant Construction

THE PROBLEM of visualizing plant layout and location has been effectively surmounted by Display Studios of Pittsburgh with the use of transparent plastics models. The synthetic rubber factory illustrated, constructed to scale for the Blaw-Knox Company, is an example of many such plants this firm has designed and built.

The walls, floors, and partitions of this model are made of Plexiglas, aviation's standard transparent plastics used for the familiar bomber nose and other aircraft enclosures.

Construction of even the most intricate mechanical models for study or demonstration is simplified with the use of Plexiglas; not only can it be cut to size with ordinary saws but it can be drilled and machined like soft metals.

YOUTH AND AGE

Both Have their Places In the Advance of Science

TOO many old men are at the helm in science, which needs the originality of youth to keep pace with its opportunities for service to mankind, according to the late Dr. Thomas Midgley, Jr.

"The extension of life, resulting from the applications of those principles regarding disease, developed nearly a century ago, has produced a condition in society whereby too many men are being kept in service beyond the years when previously they would have been eliminated," Dr. Midgley said. "This is particularly true in those activities requiring originality for scientific progress.

"Their retention is denying advancement to younger men at the very age when these younger men may be expected to be entering those years when their maximum efficiency will be attained. Earlier retirement ages or transfer for men engaged in work requiring originality is indicated."

Dr. Midgley explained that he does not mean that men over 40 are of no use to society, for "it is too evident that they are. But their usefulness is distinctly of a different nature from the usefulness of youth.

"Youth is original and creative, while age is simply experience. Both are essential elements on any team that is to make for lasting progress. I am not complaining that we have old men in active service; but I do complain about having old men in young men's places."

As evidence of youth's greater creativeness, Dr. Midgley cited an unpublished Patent Office "Table of Important Inventions," ranging from the steam engine by Watt to the airplane by the Wright brothers.

Of these inventions, 85 in number, 46 were by men 35 years or less. Fifty-eight were by men under 40. Thomas Edison made the list five times, with inventions patented at the ages of 24, 27, 30, 32, and 46.

Dr. Midgley, who was vice president of Ethyl Corporation, was 33 when he attained fame by his discovery of tetraethyl lead, which has made possible spectacular advances in automotive and aircraft engines, and which has contributed vitally to the success of Allied air power on the world's battlefronts.

The Patent Office list, prepared some years ago, begins with Sir William Perkin, inventing aniline dyes at 18. Then come William Siemens at 20 with the steam engine governor, Bessemer at 21 with electroplating, Marconi at 21 with his first patent on radio, Edison, who at 24 patented the stock ticker, Howe at 26 the sewing machine, Whitney at 27 the cotton gin, Watt at 29 the steam engine, Bell at 29 the telephone, Mergenthaler at 30 the first linotype, Nobel at 34 dynamite, Eastman at 34 the Kodak camera, the Wrights the airplane at 34 and 38, Fulton at 36 the submarine, Goodyear at 39 with vulcanization of rubber.

Fulton at 42 patented his steamboat, Siemens at 44 the dynamo and open hearth process, Stephenson at 45 the first successful locomotive, Morse at 46 brought out the telegraph, Roentgen made his x-ray apparatus at 50, Daimler patented his gasoline vehicle at 52, and Harvey patented Harveyized steel at 67, the end of the list.

The original work leading to a patentable invention often is done some time before the actual invention itself results, and this must be considered in trying to reach a true measure of the originality factor for various age levels.

Dr. Midgley concluded: "For genius and display, take youth; for cold calculation and planned execution, take age."

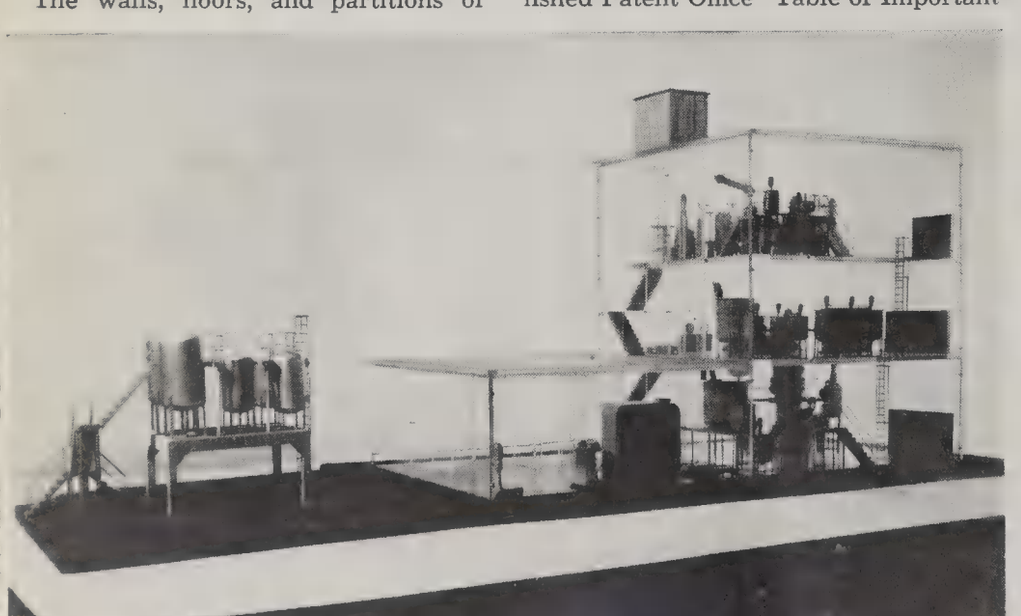
WELDING MACHINES

No Longer Cause Power-Line Troubles

IMPROVEMENTS in the design of resistance welding machines, together with excellent co-operation between manufacturers of resistance welding machines, power company officials, and resistance welding machine users, have solved the power load problem and eliminated the difficulties encountered 10 to 15 years ago when resistance welding equipment was connected to power lines.

This opinion was voiced by Mr. A. D. McLay, vice president of The Detroit Edison Company in charge of sales, during a talk before a recent meeting of the Resistance Welder Manufacturers Association.

Years ago, the installation of resistance welding machines caused power companies considerable trouble because the electric lamps of other consumers would flicker, grow dim, or almost go



Scale model of a factory, constructed of clear plastics

out when the equipment was used. In addition, it caused interference with the power supply of nearby factories and was responsible for numerous complaints from other customers.

Design improvement, plus better co-operation between resistance welder manufacturers, the power companies, and users, have enabled them to determine the power load required and take steps to anticipate difficulties before they actually occur. This may be done through the installation of a motor generator set, running in lines to take care of the extra load, and at times isolating sections of sub-stations to meet load requirements.

RUBBER-TO-METAL
Adhesive Shows
Great Versatility

DEVELOPMENT of an adhesive that is increasing the service of thousands of American combat vehicles and aircraft, and that is conserving tens of thousands of hours of manpower for war production, was reported recently by L. R. Jackson, executive vice president of The Firestone Tire and Rubber Company.

The adhesive was described by Mr. Jackson as the only one that will bond any synthetic rubber to metal. This means that it eliminates involved, time-wasting, and costly steps in many manufacturing processes where rubber must be bonded to metal.

"In addition, the new adhesive has the greatest bonding strength of any now known," he said, "and consequently permits longer and more efficient service by the dozens of rubber-to-metal bondings in aircraft and combat vehicles."

Many metals, he explained, formerly had to be brass-plated before they could be bonded to synthetic rubber. The new cement not only eliminates this step but provides a more uniform adhesion than is possible through the brass-plating method.

The presence of spots of water or rust film, both of which destroy the effectiveness of other cements, does not affect the adhesive.

This cement is particularly valuable, Mr. Jackson pointed out, in bonding rubber to aluminum, which can not be successfully brass-plated. Since aluminum and magnesium are the key metals in the aircraft industry, the new adhesive has a very important role in that field, and will be equally valuable for use with the light metals scheduled for post-war automobiles.



Ingenious New Technical Methods

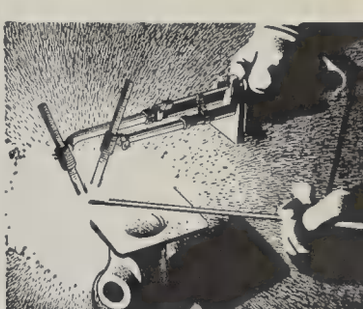
Presented in the hope that they will prove interesting and useful to you.

New 9000° Arc Torch Can Be Used for Welding and Brazing All Ferrous and Non-Ferrous Metals and Alloys

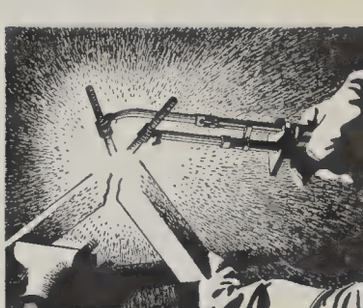
Now an arc torch that makes it possible to do most jobs *electrically* that previously were thought possible only with gas. This attachment for arc welders provides an independent source of heat by means of two carbons. It is capable of producing intense heat, approximately 9000° F., over 2000° hotter than an oxyacetylene flame. Pure heat, no oxygen or gas to contaminate the weld. No pressure to force the molten metal away or blow holes in light sections.

Developed to capitalize to the fullest on the time-saving advantages of electric welding, the new Mid-States 9000° arc torch can be used with any AC or DC electric welder. It opens up new horizons of service in this field, never before possible with an electrically operated instrument.

New uses are being found every day for products that have been familiar to us for years. Wrigley's Spearmint Gum, always enjoyed for its chewing satisfaction, is now proving with the fighting men overseas many benefits which will be useful to you in peacetime. One of the big factors in mass production is the alertness and efficiency of the man on the job. The chewing of Wrigley's Spearmint will help keep you alert and wide-awake during those work periods that, while seemingly dull and monotonous, call for watchfulness in order to get perfection in the final assembly.



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You can get complete information from Mid-States Equipment Co., 2429 South Michigan Ave., Chicago 16, Ill.

Y-168

VITAMIN-A SOURCE
Seen in Leaf Wastes
From Vegetables

WASTED leaves from carrots, beets, and spinach are rich sources of carotene and vitamin A, according to studies reported to the American Chemical Society.

One possible use of this vitamin A is in feed supplements for animals, thus turning back to the farm food value salvaged from material formerly wasted.

The new experiments, testing several different methods of extraction, obtained from leaf wastes deep red carotene concentrates equivalent to 20,000 to 200,000 International Units of vitamin A per gram, say Monroe E. Wall, Edward G. Kelley, and J. J. Willaman of the United States Department of Agriculture's Eastern Regional Research Laboratory, Philadelphia.

"Although they may vary within wide limits, spinach, beet, carrot, turnip, kale, and brocoli leaf wastes, when properly collected and dried, have an average of 300 to 700 micrograms of carotene per gram," they add. "Hence it is conceivable that carotene concentrates may be economically prepared from these materials."

The three researchers described a number of methods for preparing carotene concentrates from vegetable-leaf meals, most of them based on the rapid saponification of chlorophyll in petroleum ether solution, followed by adsorption treatment with dehydrated lime.

The methods developed will be tested in a pilot plant to determine their suitability for commercial production of vitamin A as a food or feed supplement.

DRAFTING INSTRUMENTS
Now Made Precisely from
Plastics Materials

PRODUCTION of vitally needed drafting instruments has been materially increased through developments by

Pereles Brothers, Inc., which makes possible greater accuracies in thermoplastic molding than ever before.

In some cases, instruments such as triangular relief facet scales are being produced complete and ready for use in 24 hours by thermo-plastic molding, compared to the two to three years formerly required for boxwood alone or celluloid-faced boxwood scales. Seasoning of the boxwood took 24 months, and if celluloid was applied, another 12 months was required for it to set and cure properly.



Injection-molded plastics make high-precision scales and drafting tools

All the instruments are being produced by the injection molding process, and several different types of plastics materials are used. However, it is the accuracy and precision achieved by Pereles in the dies for the various instruments that has made their production possible. Using special equipment and special methods in its own engraving, tool, and die departments, the company has been able to maintain a dimensional tolerance of one half of one thousandth of an inch per inch between lines as delicate as three to three and one half thousandths of an inch in width.

Another step forward in the engraving of the fine dividing lines in the Pereles plant is that the lines are deeper than they are wide, which increases the life of the instruments and also make it far easier to wipe in the color.

Plastics used in slide rules are Lucite, made by Du Pont; Plexiglas, made by Rohm and Haas; and polystyrene, made by Bakelite, Dow, and Monsanto. The five-inch types are made of Lucite or Plexiglas and polystyrene. The ten-inch slide rules are made entirely of Lucite or Plexiglas.

High precision likewise is attained in the other instruments now being molded by Pereles. Calibrations on the triangular relief facet scale for engineers are in tenths, twentieths, thirtieths, fortieths, fiftieths, and sixtieths of an inch. The triangular scales, as well as flat four-bevel scales for architects and engineers in 6-inch pocket size and 12-inch standard size, are molded either of Lucite or Plexiglas.

GOLD-PLATED MOLDS

Increase Production of Plastics Fixture

Fifty thousand man-hours represents a lot of time and a lot of valuable manpower, especially if that manpower is made up of highly skilled tool makers.

That was the time, nevertheless, which, with the ordinary procedure, would have been necessary to complete an order for a vitally essential fixture (it's still a military secret) for a branch of one of the Armed Services. The need for this part was urgent.

The use of conventional methods was out of the question. That would not only have taken 50,000 man-hours but, to complete the order, thousands of pounds of precious tool steel. The contract had been given to the Eastman Kodak Company so it was up to Kodak to produce.

Kodak chemists proved first that the fixture could be molded of a casting resin instead of steel and thus made the first cut in cost and time. But then too much time was consumed in painting the original mold after each casting to permit the release of the molded plastics. There was another huddle of chemists and they came up with the answer. By gold plating the original mold—a method never before used—the increase in production was almost unbelievable. They could produce the fixture with this method at the rate of four an hour or about 60 times faster than would have been possible with the old accepted method. This method also resulted in much closer tolerances and a smoother over-all finish.

LIGHTNING

Not a Power Source, but Beneficial in Other Ways

Man's dream of harnessing lightning flashes for electrical power has been kicked into the realm of scientific nonsense, according to studies made by Dr. Gilbert D. McCann of the Westinghouse Electric and Manufacturing Company, who recently stated that investigation has shown that the maximum electrical energy that could be obtained from the two billion lightning strokes that annually bombard the total earth's surface is approximately 175 billion kilowatt-hours per year.

"In contrast," the scientist, whose reports on lightning are internationally known, added, "the American power station industry alone last year generated 221 billion kilowatt-hours—about one third of the total electric energy generated in the world. These men have outdone nature on a major scale and have, through engineering skills, set aside the wild dreams of men who would harness lightning."

Dr. McCann explained that while lightning carries a terrific wallop, its usable energy is only of momentary duration.

The powerful strokes that rip into buildings, split trees, and sometimes kill human beings release energy at a very great rate. For example, a stroke can momentarily produce upwards of 200,000 amperes—enough current to light two hundred thousand 100-watt light bulbs or a city of about 30,000 population. However, it could do this only for a fraction of a second.

At the same time, Dr. McCann said, lightning serves two very useful purposes—releasing nitrogen from the air and charging the earth's crust with electricity.

"Lightning is much like rain," he continued, in that it is "a sudden tangible precipitation that has been accumulating slowly and invisibly. In the spectacular show that lightning stages, the stroke itself, the thunder it creates, and the damage it causes are visible actors. But they are only three fourths of the cast. The unobserved principal is the constant flow of electricity from the earth to the clouds.

"To offset this loss of electricity, the earth's surface must be struck by lightning at the average rate of 50 times a second, or about two billion times a year."

Nitrogen is produced for the earth's surface in this way: The action of the thunderbolts in streaking through the atmosphere releases nitrogen from the air. In the form of nitric acid, the nitrogen falls in rain drops and enriches the soil. "In this way," Dr. McCann pointed out, "lightning annually produces nearly 100 million tons of nitric acid—more of this soil builder than is manufactured by all the world's fertilizer plants."

LIGHT PLASTICS

Has Many Insulation, Flotation Possibilities

Plastics foam weighing only one seventh as much as cork has been developed and is being manufactured by United States Rubber Company. Important peace-time uses foreseen include insulation for trains, airplanes, automobiles, and homes and in life-saving equipment such as life preservers and floats.

Although it has great buoyancy, it is semi-rigid. Because it contains so much air space, it has good insulation and sound-deadening properties in comparison to its weight. It weighs less than a pound and a half a cubic foot and can be made to weigh as little as three quarters of a pound per cubic foot.



New plastics foam has insulating qualities, is extremely light weight

To produce the new and different war material, a combination of synthetic plastics materials are foamed and then solidified. The new product is called "flotofoam" because of its buoyancy.

New Products

DIAMOND DRESSER

WHEEL dressers made with small commercial diamonds set into a matrix of Carboloy cemented carbide are being used to true-up recesses in finish grinding wheels employed to grind aircraft cylinder sleeves.

When a conventional single diamond dresser was used for the recessing operation—which is necessary in order that the grinding wheel may produce a sharp corner at the bottom of the cylinder sleeve's flange—the holder had to be ground flat and the diamond lapped so that the stone would perform the dishing-out operation correctly without the holder touching the edges of the recess.



Dressing a recessed grinding wheel

The Carboloy diamond-impregnated dresser, on the other hand, contains diamond particles distributed throughout the matrix, thereby insuring that at least one or more of the stones will be in contact with the grinding wheel at all times as the holder is swung through a small arc. Moreover, new cutting faces are presented to the abrasive wheel as layer after layer of diamonds are reached and exposed, due to the gradual wearing-away of the carbide matrix. Hence no lapping and no re-mounting are needed as in single diamond dressers.

HANDSAW RETOOTHER

THE NEW Burro automatic handsaw retoother will, it is reported, do a perfect job of punching a perfect set of new teeth in an old handsaw in less than one minute. The retoother consists of a punch and die mechanism, a drive wheel, a feed mechanism, guide blocks, and clamps with adjustable spring tension, all assembled and mounted on a base. A ¼ horsepower electric motor furnishes the necessary power. Five index bars are supplied to provide any desired retoothing for either cross-cut or rip.

To retooth any hand saw, the handle is first removed. The proper index bar is selected, placed in the saw carrier and tightened in place with two C clamps. Next, the bed-plate is swung to the proper angle for cross-cut or rip saws and tightened. The saw and carrier are then inserted into the machine from the left until the index bar is under the pawl, and power is applied. The teeth are punched out one at a time in rapid succession (240 per minute) until complete retoothing is accomplished. It is unnecessary to cut or grind off the old teeth—they come off as chips. The new teeth are ready for setting and filing.

VERSATILE WELDERS

TWO "post-war" additions to their new storage-battery powered line of resistance welders have been announced by Progressive Welder Company. The first of the new additions is an "economy" spot-welder of the rocker-arm type, completely self-con-



THE HENRY SYSTEM Of Finger Print Classification and Identification

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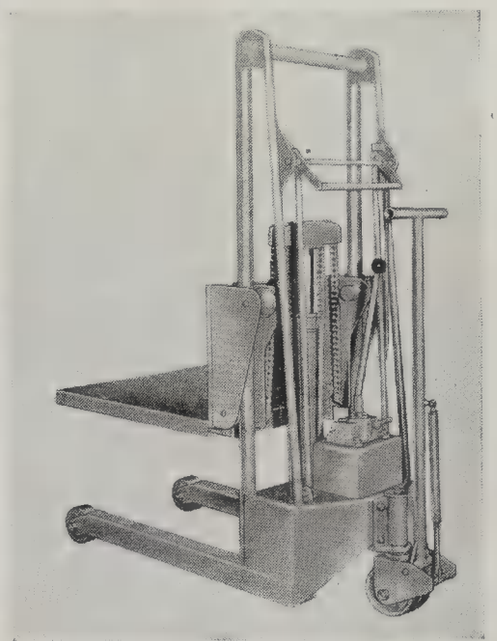
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tained, with storage batteries, contactor-controller, and infinitely variable heat-control regulator all enclosed in the base. The second machine is of the heavy-duty type and designed so that both spot- and roll-welding can be performed on the same machine with but minor changes. Batteries for this type of machine are housed—with contactors, battery chargers, and controllers—in standardized "power-pack" units.

In addition to ability to weld conventional steels with these welders, both models are designed to handle spot welding of such important "post-war" materials as stainless steel, aluminum, and so on.

HIGH-LIFT TRUCK

WHAT is said to be a definite departure in material handling equipment, developed and introduced by Lyon-Raymond Corporation, is a combination of a lift truck and a tiering machine. This hydraulic high-lift truck is exceedingly light in weight compared to equipment designed to do this one phase of material handling, which accounts in a degree for its movability. It turns readily within its own length. It is made of special tubular and formed steel construction and is Timken equipped. A powerful floor lock and fingertip controlled lowering device are features.



Light in weight, easily maneuverable

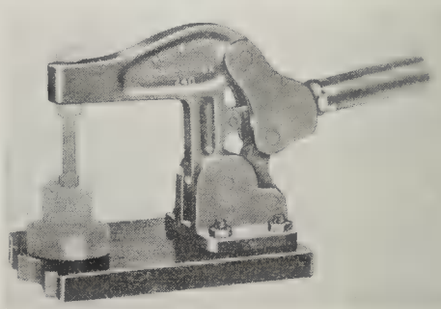
COMPRESSED AIR PURIFIER

DESIGNED to eliminate free moisture, oil, and all foreign matter with a heavier specific gravity than air from passing through compressed air lines, a new purifier has just been developed by the Bird-White Company.

Known as the Model A-1 Pur-O-fier, this new unit uses positive centrifugal action as a medium for purification. It weighs only 1¼ pounds and is just 3⅛ inches in diameter by 5 9/16 inches deep including plastics and transparent entrainment sump. No maintenance is required on the unit other than draining the sump, which can be easily accomplished by opening the petcock in the bottom. For intermittent operations the new Model A-1 Pur-O-fier is extremely sensitive to the slightest movement of air and provides positive purification of air lines at all times. It can be used in connection with many air-operated devices, more specific applications being dental machines where absolute cleanliness is a requisite; production lines where parts must be kept clean for assembly; and compressed-air units for offset spray devices.

CLAMP

THE Cam-O-Lok clamp, developed by Mechanics Engineering Company, is made in three types, for light, medium, and heavy duty. The clamp is instantly adjustable over the entire range of its vertical holding capacity. When objects to be held vary in thickness, no adjustment of the hold-down bolt is necessary to obtain the desired clamping pressure. Locking and unlocking are accomplished by means of a threaded element in the positioning handle. Lubrication is provided for the threads.



Readily adjustable over wide range

APRONS

LIGHTWEIGHT laboratory and industrial aprons made with high-grade cotton fabric and a vinyl-resin coating are particularly well suited for operations in laboratories, battery shops, tanneries, canneries, machine shops, and on the farm.

The vinyl-resin coating makes the Goodrich aprons water-proof, acid-proof, alkali-proof, and oil and grease resistant. They are flexible and constructed with hemmed edges and reinforced neck and waist tapes.

PAINT STRIPPER

A HIGHLY efficient water-soluble paint stripper that loosens paint for speedy removal with water has been developed by Turco Products, Inc. According to the manufacturer, the hosing off of an application of this stripper leaves a clean, paint-free surface requiring very little after treatment to prepare for further processing.

The new material, known as Turco Stripper L-780, is claimed to be non-corrosive on metals, making it safe for use on any aircraft part or assembly and recommending it for the removal of zinc chromate primer as well as other paint coatings. It is said to be safe for use on wood and to cause no tendency to warp.

Due to the water-soluble characteristic of Stripper L-780, brushes and

cleaning equipment can be cleaned for re-use quickly and completely by a vigorous churning in a bucket of water.

Applied with brush or spray, the material is left on the surface until it tests ready for removal (5 to 20 minutes). Loosened paint is scrubbed with a water saturated brush to form a slurry. Slurry is then removed by hosing with water, steam, or air and water gun.

ROLLER TOP

For use with the Lyon-Raymond hydraulic elevating table, a new removable and reversible roller top is now available. Instant installation or removal of the roller top is possible since the framework fits down over the permanent top, eliminating any necessity for bolts or other fastenings. The roller top consists of a rigid, welded framework, supporting ball-bearing conveyor rolls.

Since the table top is square, the roller top can be placed to convey from front to back, or from side to side. This understandably increases the



Useful in conveyor systems

table's usefulness for a great many applications. With the roller top, the hydraulic elevating table is commonly used in conveyor systems to accomplish a change in level or direction. It is also highly desirable in many die handling and feeding operations.

SWITCH BREAKER

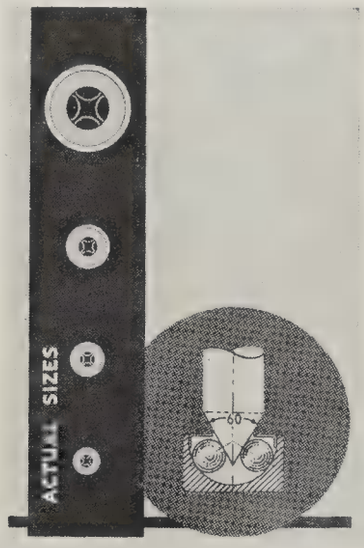
Relatively free from the effects of extreme high and low temperatures, a new circuit breaker is announced by Littelfuse Incorporated. The actual trip temperature of the new breaker without flow of current is 350 degrees, Fahrenheit, ambient temperature. This outstanding resistance is accomplished by new bi-metal design. There is, of course, a clear distinction between operating and ambient temperatures. The high differential between operating and breaking temperatures is a distinguishing characteristic of this circuit breaker.

The bi-metal is used as the finger that pulls the trigger. No appreciable mechanical load is exerted on the bi-metal as it trips the breaker. Thus a new degree of dependability and uniformity of performance is reported.

While primarily designed for military uses—aircraft, tanks, ships, landing craft, and so on—the high time lag of the breaker well adapts it to protection of motors and other equipment having high starting surge currents.

PIVOT BEARINGS

Pivot type ball bearings are now available from Miniature Precision Bearings in sizes ranging from 2 to 10mm outside diameter and made of beryllium,



Small bearings now available

stainless, or chrome steel as required for the application. The bearing races are machined from solid bar stock and highly finished on raceway and exterior surfaces. Each bearing is equipped with four balls of the same material as the cup and fitted with a retaining cap.

BLACKENING PROCESS

Chemical blackening of ferrous parts can now be accomplished by a new and simple process which utilizes immersion equipment that can be set up quickly in small manufacturing or plating plants with equipment that is already available or obtainable at very small cost.

The Ferrotone bath, developed by Turco Products, Inc., operates at a temperature considerably below that re-

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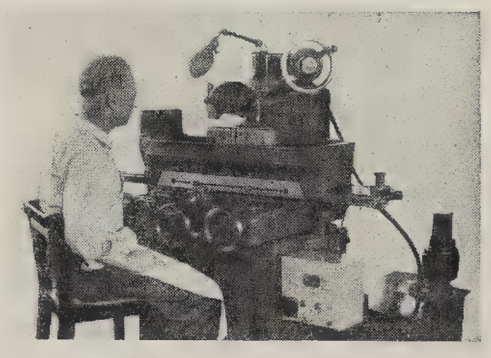
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quired by oxide finishing baths. Ferrotoning, an entirely chemical process, provides a gleaming black or rich matte finish which is integral with the metal itself and is extremely durable. It does not chip, flake, or peel even under repeated flexing. It will not blister and can not be removed under routine cleaning operations by the action of solvents or degreasing agents. The process neither increases nor decreases the dimensions of the treated metal.

SURFACE GRINDER

LATEST developments in balance and construction give the new model G-1 DoAll surface grinder a dependable accuracy which enables even "green" operators to rely on the machine for constant fine work. With standard grit wheels, the machine produces a fine finish to within six micro-inches. An innovation in design permits the operator greater convenience and closer inspection of the work while grinding.

Built for tool room use and light production work where accuracy is paramount, it has a table travel of 21 inches and transverse travel of 7½ inches with a vertical wheel head adjustment of



Grinding accuracy is built-in

12 inches, using a 7 by 1¼ inch wheel. Extreme rigidity, so important to precision finish, is inherent in the 2200-pound machine. This is almost double the weight usually found in a tool room surface grinder. This great weight, while helping to absorb vibration, is also used to advantage at all vital points.

An especially constructed combined hydraulic control unit eliminates all piping usually found in a surface grinder of this type. This one unit controls the five hydraulically actuated movements of the machine.

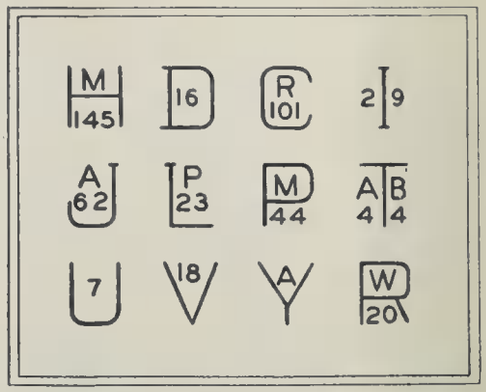
PLATING ON GLASS

THE UNUSUAL adhesion obtained by Electro Plastic Processes in plating on plastics materials has been further adapted for application to glass and ceramics. Laboratory and field tests indicate greatly improved hermetic sealing. Tests on Pyrex glass have been conducted by heating the solder-sealed piece to 350 degrees, Fahrenheit, and immersing it immediately in dry ice, indicating the adaptability of the new process for all temperature ranges. Adhesion obtained is reported to be much better than that of other commonly used methods.

Any normal soldering method is satisfactory—hot iron, oven soldering or electronic, and no special solders are required. Either glass or ceramic cases can be plated with a metallic band for soldering to metallic end caps, or insulators plated for solder sealing to metallic containers.

IDENTIFICATION STAMPS

HAND stamps by which even more information can be conveyed than by conventional hand stamp designs are now available from New Method Steel



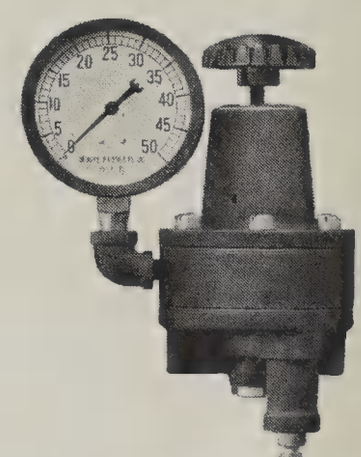
Possible variations almost unlimited

Stamps, Inc. These new "Letter-Outline" stamps are particularly suitable, for example, where several sub-contractors may be making the same part and shipping them into the contractor's plant in quantities. With the new hand stamps, not only is it easy to identify the company which supplied the parts, but the latter company can also identify the individual operator or inspector responsible.

All such information can now be included on one hand stamp by a design which utilizes a large initial letter as an "outline" on the stamp, while other pertinent information as to operator and operation performed on the part is included within that character outline.

PRESSURE REGULATOR

A NEW regulator, designed to hold air pressures constant regardless of changes in flow as well as variations in



To hold air pressures constant

supply pressure, operates on the pneumatic "null" balance principle and may better be described as a pressure controller, since the main air valve is operated by a detecting nozzle. This nozzle operates with a constant differential pressure to hold the manual load-

ng spring at essentially the same position, regardless of variations in flow or n supply pressure.

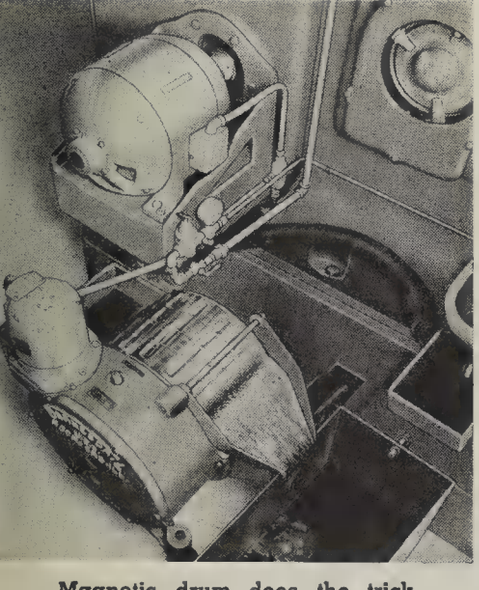
An automatic bleed is provided, to operate when a reduced regulated pressure s required. The automatic bleed also serves to permit reverse flow when the regulator is used as a limit control on ndustrial instrument applications.

COOLANT SEPARATOR

EMBODYING an entirely new method for automatically removing harmful magnetic metal and abrasive particles from honing coolants having a non-soluble base, a magnetic-automatic coolant separator has been brought out by the Barnes Drill Company. No filters are employed by the separator and all magnetic particles are automatically removed through magnetic attraction.

The separator is a self contained, motor driven unit, employing a magnetic rotary drum, which attracts metallic particles as they pass through the coolant and carries them out as the drum rotates. The drum is constructed of a series of permanent magnets mounted all the way around the inside and rotating with it.

The coolant flows rapidly in a thin

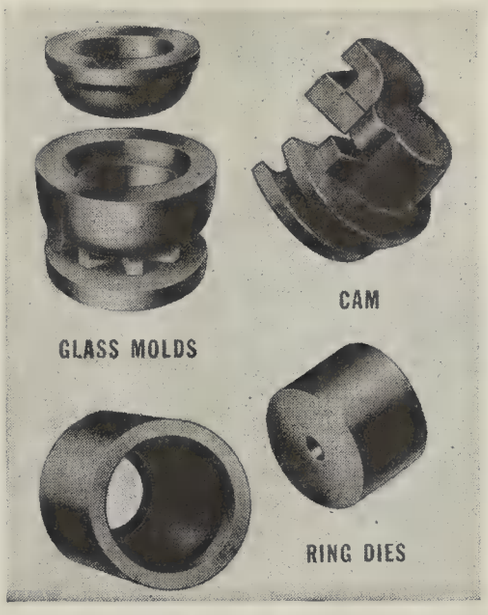


Magnetic drum does the trick

wide channel through the lower part of the separator in a counter direction to the slow rotation of the drum. The metal and abrasive particles adhere to the drum and extend on end in a definite brush-like pattern. Then, as the drum rotates, the entire sludge mass is scraped off and discharged through a chute into a movable pan. Constant swarf removal maintains reservoir storage. There is no temperature rise and the coolant returns to the reservoir into the base of the machine, ready for immediate recycling.

CAST-TO-SHAPE STEELS

TOOL steels are now being cast-to-shape for commercial applications by the Cast-to-Shape Division of Jessop Steel Company. Finding wide application in industry, cast-to-shape tool steels are used for dies, forming tools, glass molds, gages, hobs, gears, cams, and numerous other items. Advantages that may be obtained by using this process include savings of time, labor, material, and machining costs. These savings are most noticeable in the case of tool steel dies needed for immediate production, for the die is cast to the shape in which it will be used and requires only a minimum of machine finishing. All castings are furnished in the annealed condition to facilitate machining.

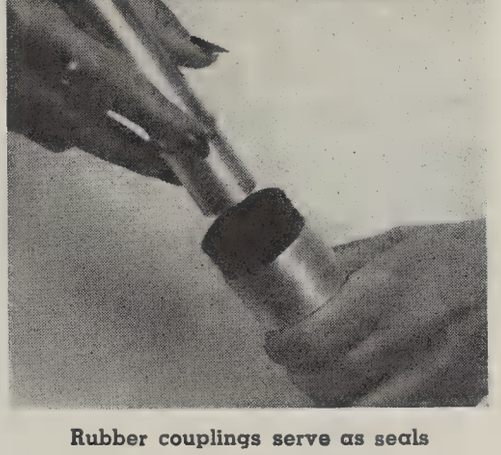


Examples of cast-to-shape parts

Standard types of tool steel castings are regularly being made, in the latest types of casting equipment, of air hardening, oil hardening, flame hardening, stainless and heat resistant analyses. Many other analyses of specialty steels are available and even the user's "tailor-made" specifications may be cast to shape.

COUPLINGS

RUBBER couplings which have had conspicuous success in many parts of the pipe-laying field have now been adapted



Rubber couplings serve as seals

to other uses, it is announced by The B. F. Goodrich Company. The coupling is effective as a seal or as a flexible joint, and is particularly valuable in applications where vibration might cause metal-to-metal couplings to fail.

The Flexlock coupling is a gasket or ring having ribs or fins running circumferentially both inside and outside. Inside fins not only grip the outside surface of the smaller pipe but also furnish a maximum sealing pressure. The outside fins are so designed that deformation of pack takes place

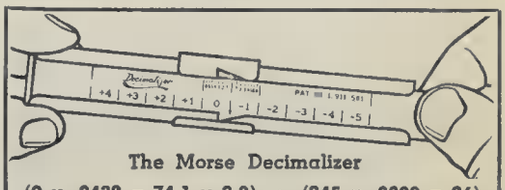
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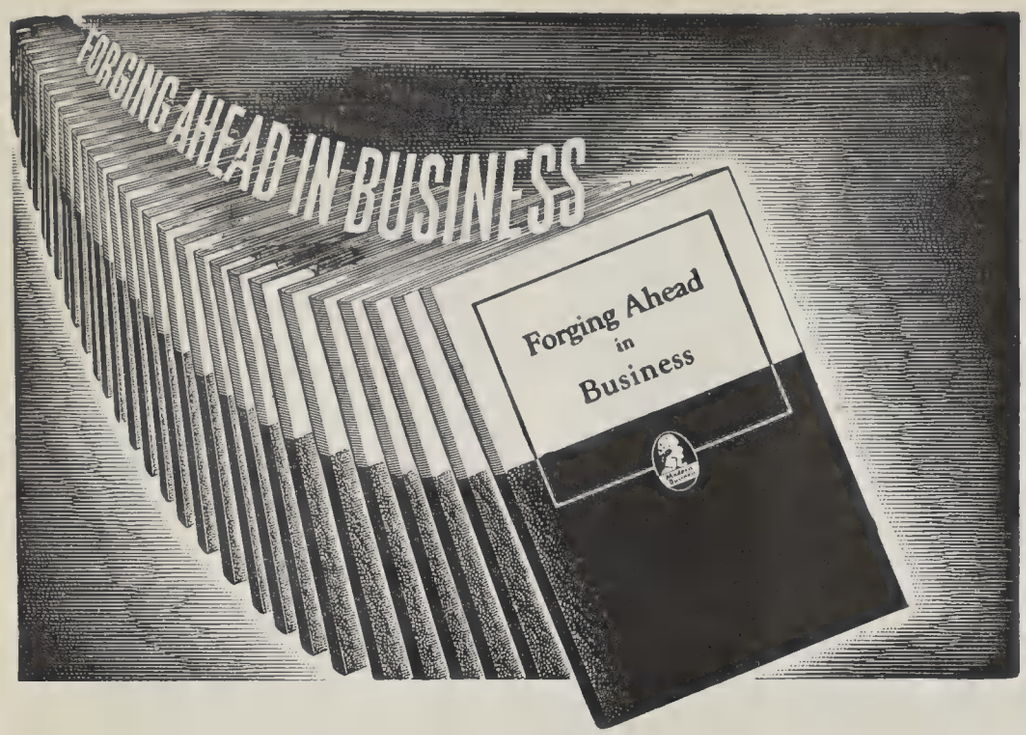
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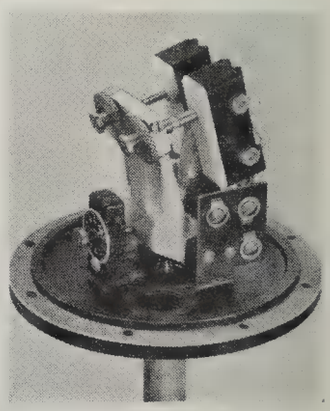
and they grip to the bell or sleeve of the outer pipe. They also set up strut action through the cross section of the coupling, driving the joint tighter.

The result of the gripping action of the inside fins and the sectional thrust caused by their deformation is an absolutely tight joint. Through the design of the outward lips, the only effect of internal pressure is to drive the gasket up the tapered seat, wedging the rubber into a position for even tighter packing.

The couplings can be made of either natural or synthetic rubber, depending upon service conditions. Various compounds to meet specifications have heat ranges from —50 degrees, Fahrenheit, to 150 degrees, Fahrenheit, and can be made resistant to petroleum products and aromatics, as well as hot and cold gases and liquids, the latter including commercial acids, alcohol, water, gasoline, and oil.

TEMPERATURE LIMIT SWITCH

A NEW temperature limit switch offers all of the well known features that have made Burling switches famous, plus the following new ones: Water- and vapor-tight sheet metal cover; switch adjusting screws have locking screws instead of disks to lock adjustment; main temperature can be easily locked in place with a screwdriver instead of the usual wrench.



Interior of new temperature control switch with wide working range

Burling Temperature Limit Switch Model VD-20 can be used for any temperatures from minus 100 to plus 1400 degrees, Fahrenheit.

POLISHING-WHEEL CEMENT

AFTER extensive research, Michigan Bleach and Chemical Company has announced a new synthetic polishing-wheel cement, "Gripmaster," which promises to find wide use in many metal polishing operations.

Due to a high-heat-resisting ingredient, Gripmaster does not "glaze" on the wheel. Moreover, it is reported that its adhesive action "locks in" the grains of emery with a positive "vise-tight" control never before believed possible.

A time-saving and inventory-reducing advantage of Gripmaster, it is said, is that all grains—250 to 20—may now be applied with just one grade of cement. It is now no longer necessary to stock several different grades of adhesives for different metals, different flexibilities, or different temperatures. Gripmaster's one grade fits them all.

Current Bulletin Briefs

Conducted by K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

A PLAN FOR AMERICA AT PEACE is a 44-page booklet profusely documented with color charts and graphs, all aimed toward promoting smoothly functioning relations between labor and management. Employment statistics, past and present, are analyzed and lengthy discussions devoted to demobilization, reconversion, full employment, and other industrial problems. *Electronic Corporation of America, 45 West 18th Street, New York 11, New York.—Gratis in the United States and Canada.*

ENGINE BEARING MANUAL is a 96-page well illustrated manual for mechanics and others interested in automotive engine maintenance. It contains information on the proper selection and installation of bearings, with tables showing crankshaft and bearing dimensions, tolerances, and oil clearances for all makes of cars, trucks, buses, and tractors. *Clawson and Bals, Inc., 4701 West Lake Street, Chicago 44, Illinois.—Gratis.*

TRACER-CONTROLLED ARC ETCHERS is an eight-page booklet describing in detail single- or multiple-head etching machines for use in light or deep etching of all metals of many sizes. Request bulletin 1635-B. *George Gorton Machine Company, Racine, Wisconsin.—Gratis.*

SPRINGS DESIGNED FOR THE JOB IMPROVE PRODUCT PERFORMANCE is an eight-page booklet which defines and illustrates the five basic types of springs and a variety of shapes and sizes into which they can be designed. *Muehlhausen Spring Corporation, 201 Michigan Avenue, Logansport, Indiana.—Gratis.*

THE VISMETER is a 24-page brochure presenting an exposition of a device for the continuous measurement of the viscosity of fluids, with automatic recording. *Carl D. Miller, Ph.D., 327 Salem Street, North Andover, Massachusetts.—$1.00.*

SAFETY IN ELECTRIC AND GAS WELDING AND CUTTING OPERATIONS is a bulletin compiled to provide safety to both personnel and property in welding, cutting, brazing, and lead burning operations. *American Standards Association, 70 East 45th Street, New York 17, New York.—40 cents.*

SPEEDAIRE WORM GEAR REDUCTION UNITS is a 14-page catalog outlining in detail the principle of the Speedaire fan cooled system by means of photographs, charts, diagrams, and engineering tables. Carefully detailed instructions for planning installations of Speedaire units are included, together with rating tables, dimensions, and shipping weights. *Cleveland Worm and Gear Company, 3301 East 80th Street, Cleveland 4, Ohio.—Gratis.*

TURBINE CLEANING MANUAL is a 16-page booklet outlining a new technique for solvent-cleaning of turbines by the use of Shell Turbo Cleaner. With good dehydrating properties and high solvency for oil deterioration products, this new cleaner has a high concentration of anti-rust agents and can be used on both new and old installations. *Shell Oil Company, Inc., 50 West 50th Street, New York 20, New York.—Gratis.*

WELTRONIC HEAT CONTROLS—Number WTH-44—is a technical bulletin containing descriptions, applications, specifications, and features of an improved line of unit heat controls, available for many resistance-welding processes. *Weltronic Company, 19500 West Eight Mile Road, Detroit 19, Michigan.—Gratis.*

THE USE AND CARE OF MICROMETERS is a 24-page illustrated booklet which describes in detail the various parts of a micrometer, explaining how to use and take care of it. The importance of frequent checking to insure accurate readings is emphasized and suggestions for prolonging the life and serviceability of the instrument are listed. *Sav-Way Industries, Box 117, Harper Station, Detroit 13, Michigan.—Gratis.*

ECCENTRIC DRIVES is a 20-page catalog describing a new counterbore and special high speed steel cutting tools. A full description of each type is presented, including tables of sizes, cross-sectional views, and decimal and millimeter equivalents. *Moreland Tool Company, 16935 West McNichols Road, Detroit 19, Michigan.—Gratis.*

REX FLAT SPRAY NOZZLES is an eight-page folder outlining the uses of nozzles in cleaning, cooling, and washing operations, with tabular information concerning their discharge in gallons per minute, their dimensions, and available sizes. *Chain Belt Company, Milwaukee, Wisconsin.—Gratis.*

BL METALLIC RECTIFIERS is a four-page bulletin containing pertinent information on the characteristics and applications of metallic rectifiers adaptable to electronic, radar, and automotive battery charging equipment. *The Benwood Linze Company, 1815 Locust Street, St. Louis 3, Missouri.—Gratis.*

DESIGN AND CONSTRUCTION OF PNEUMATIC TIRES is a 50-page manual published for United States Army training schools and now available to civilians. The basic principles of pneumatic tire design are described and illustrated. Data and tables are given on the important classifications of heavy-duty military and civilian tires. *B. F. Goodrich Company, Akron, Ohio.—Gratis.*

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PRODIGAL GENIUS: THE LIFE OF NIKOLA TESLA

By John J. O'Neill

THAT Nikola Tesla gave to the world the fundamentals of the alternating current power system is indisputable; but that he should be credited with the discovery of the modern radio system, the planning of present broadcasting methods, the invention of fluorescent lamps, and a dozen and more other things that Mr. O'Neill ascribes to him is something that is open to serious question. Beyond a shadow of doubt Nikola Tesla was a mental genius whose powers were far greater than those of even some of the most brilliant men of today. Lacking in practical business ability, however, he becomes an eccentric figure in the world of science, alternately ignored and acclaimed. The story of Tesla needed telling and it is told here in complete detail. If the reader will overlook the mysticism that is woven through the book and will forgive the author for "superman," "dazzling scintillations," "intellectual incandescence," "a single mighty burst of invention," and similar gasps of amazement, he will be able to mine out of the pages of this biography a picture of one of our truly great scientists who all too often fell short of fulfilling his lavish promises to humanity. (326 pages, 6 by 9 inches, a portrait of Tesla.)—$3.85 postpaid.—*A.P.P.*

ELEMENTARY MATHEMATICAL ASTRONOMY

By Barlow and Bryan

OLD favorite, a half century in existence, lately out of print and unobtainable, but now back in a fifth edition revised by the Astronomer Royal, who has rearranged it and brought up to date the exposition of the basics. Mainly, however, mathematical astronomy is timeless. Those who do not love mathematics regard such books as bleak. This one for the beginner requires only algebra, geometry plane and solid, trig, no calculus, and isn't downright wantonly, perversely, and maliciously bleak but only tenderly bleak, as if the authors had said this hurts me worse than it hurts you. Coverage: celestial sphere; time; earth; sun's apparent motion in ecliptic; atmospheric refraction and twilight; geocentric and annual parallax; aberration; eclipses; planets; precession and nutation; observatory; earth's position; solar, stellar distances; rotation of earth; gravitation. (387 pages, 5½ by 8¼ inches, 170 illustrations.)—$5.10 postpaid.—*A.G.I.*

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By Grace Lee Nute

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By Harold F. Dodge and Harry G. Romig

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN 1931, Daniel E. McGuire, a Shadyside, Ohio, farm lad then 17, hit on the use of a slit in place of a pinhole in the telescope mirror maker's Foucault knife-edge test and for this his name has been in the book "Amateur Telescope Making" (page 380) since the edition of 1933. Later, McGuire became a precision optical worker for several professional producers. In June, 1943 he hit on something which he now, by invitation, describes after using it a year and becoming closely familiar with it—the employment of spacers of scotch tape in connection with the air-spaced test plate for optical surfaces. From 15 Lincoln Ave., White Plains, N. Y., he writes:

IT is commonly believed by opticians that interference fringes appear between optical surfaces only when they are in close contact with each other. This is the earliest form of optical testing in which the interference of light waves reveals minute irregularities on the surfaces. This method prevails to the present day. It has many disadvantages, but they can be overcome to a great extent through the use of air-spaced test plates.

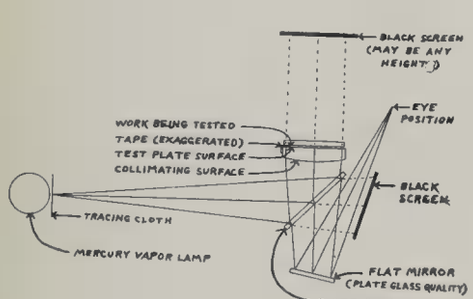


Figure 1: Inverted method

With the use of monochromatic light, a surface may thus be tested when removed many thousands of wavelengths from the test-plate surface. While there is no need for going to this extreme, there are many advantages in separating the two surfaces as much as 100 wavelengths (0.002"). This reduces the risk of scratching poorly cleaned surfaces, and increases speed many times over that of the conventional method.

The ideal material for separating the surfaces is scotch tape. This material is uniform in thickness and, when properly applied at three equidistant points on the test plate, it is easy to maintain parallelism between the surfaces. For 2" to 4" test plates the tape is cut to ¼" to ⅜" width and about 1" lengths. The cleaner end is applied to the surface, and the other end, because it has been handled when cutting to size, is folded down over the edge of the test plate. For this critical work the scissors must be kept clean. Any dust particles that are sealed under the tape add to the thickness of the air space, hence cleanliness must be the rule when applying the tape. For the same reason air bubbles under the tape must be avoided.

To prevent curling of the edges and corners of the tape the test-plate surface must itself be cleaned with great care. When removing a grease film from the area near the tape rubbing must begin near the center of the tape and proceed outward to the glass. Dust is removed with a soft brush.

An ordinary test plate, whether flat or curved, cannot be used with the increased air space without proper collimation of the light. The rays can be focused upon a flat, or on a curved surface by a lens system (Figure 1) on the back of the test plate, so that all rays will have normal incidence upon the surface being tested. The rays return in the reverse direction, and the collimating lens system refocuses them upon the light source.

Test plates of the usual type, optically modified by using the proper collimating systems but without spacers, are thereby decidedly improved. The fringes are more plainly visible on the steeper curves, and the readings are more dependable. Distortion due to oblique reflection angles of marginal rays does not exist in any collimating test plate unless there are serious errors in the collimating system.

An off-axis point of view distorts the fringes. To maintain alinement of the axis a small spot of paint is applied to the center of the back surface of the collimator. When its reflection is hidden by the spot itself, the point of view is on axis. Only one eye can see the undistorted pattern, since both cannot be on the axis together.

A beam splitter is essential to viewing the test plate on axis. This is a piece of glass, plane-parallel, polished on both sides, which reflects only a part of the light and transmits the remainder (disregarding the small portion that is absorbed by the glass itself). It works best with a thin coat of silver or aluminum on one side, but an uncoated beam splitter is satisfactory when the room is darkened. It makes no difference on which side it is coated, but the under surface is the more protected from dust. A piece of clear plate glass is good enough for this work. Figures 1 and 2 reveal the function of the beam splitter.

It is important that the light source be made large enough to allow for changes in the alinement of the test plate axis; the same applies to the size of the beam splitter. An excessive amount of spherical aberration in the collimator also requires a large light source to provide even illumination of the test plate surface.

Any light source which radiates a small number of different wavelengths concentrated into very narrow lines in the spectrum, is suitable for air-space test plates. Low-pressure mercury vapor lamps are better than high-pressure lamps, although the latter work well when the air space is not too great. Sodium vapor lamps are very good. Neon and fluorescent lamps can be used, but they are not recommended.

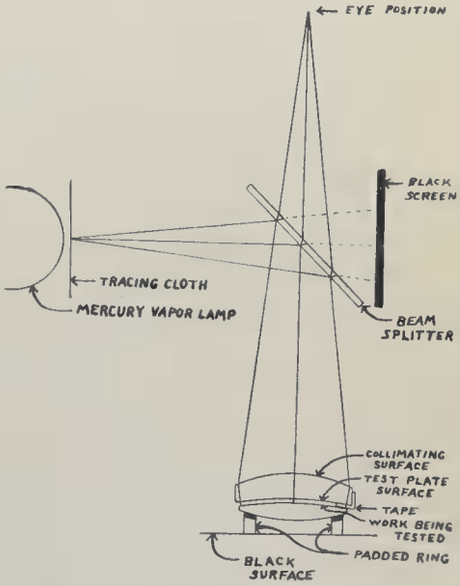


Figure 2: Direct vision testing

Other types of lamps have not been used by the writer.

The separation of two flat surfaces tested in parallel, monochromatic light, has little effect upon the reading of the fringes but with all curved surfaces the readings go concave with a widening separation of two matched surfaces, the change in the reading being in direct proportion to the amount of separation. The steeper the curves the greater the number of Newton rings for a given separation.

When curved test plates are air spaced, the test-plate surface must be altered from the true radius to a new curvature. In order to produce straight fringes, when testing the opposite curvature of the true radius, the change in radius is always made equal to the thickness of the spacers. Convex air spaced test plates are made steeper, concave ones are made flatter, than the true curvature.

When the new curvature is established, the air space must remain constant in order that the test plate can be relied upon. In practice this cannot be guaranteed, but there is another way to be sure of the test-plate reading. Although the spacers are not reliable in their thickness, the master test plate is reliable in curvature. The air-spaced test plate for steep curves therefore must always be accompanied by the master test plate. Straight fringes are no indication of the true reading unless they are seen when

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testing the master. When the master appears to be wrong, due to an error in spacing, this "wrong" reading is the correct reading for the work.

The scotch tape spacers never grow thinner with use, although they may be compressed through excessive pressure and show temporarily a convex reading. It is quite normal for the tape to collect dust around the edges while in use; it becomes lodged underneath the tape and the air space is increased. The error in spacing may change the reading as much as three fringes before it is necessary to renew the tape. When the master shows a concave reading of three fringes, the work must read the same in order to be correct. Straight fringes on the work, in this case, are three fringes convex. An excessive amount of dust is avoided when the most accurate work is desired. In flat work, or with shallow curves, it is not so necessary to check with a master.

A sodium vapor lamp, radiating light in wavelengths of 0.00002", permits the convenient use of round numbers. A surface having 18 degrees of curvature shows a change in reading of one fringe for each 0.001" change in separation. (Collimated light, having normal incidence over the whole surface, is always used in this demonstration.) Spacers having 0.002" thickness change the reading two fringes from the contact reading. A further change in thickness, while the tape is in use, changes the reading in a direct proportion with the error in spacing. A 10 percent increase in spacing changes the reading only 0.2 fringe. When testing a surface having three times the curvature, or 54 degrees, the same change in spacing causes the reading to change nine (3^2) times as much. The 0.002" spacers change the reading 18 fringes from the contact reading, and a further change of 10 percent changes the reading 1.8 fringe.

The following procedure is used when correcting the test-plate surface. The spacing material is selected first, and a fair quantity is held in reserve for future replacements. The separation of the surfaces is established by the thickness of the spacing material at hand. Testing is done on the master test plate with spacers temporarily applied to its surface. The test-plate curvature is altered until the concave readings, due to separation, are reduced to zero.

Most of the alteration can be checked by contact readings when the number of fringes is predetermined. The test plate is made to read convex. The testing is done in the usual way, without collimation. The test plate is blocked for polishing by machine, and only the finishing touches are left for hand work. The back surface is cleaned to allow testing of the final work by collimated light. Spacers are used as described above.

Spherical aberration in the collimating lens system has some effect upon the straightness of the fringes. The air-spaced test plate cannot be made spherical unless the collimator is corrected for spherical aberration. It is easier to compensate for the aberration in a simple type of collimator by producing an aspheric test plate. Ordinarily the aspheric surface is produced, without awareness of it, in striving to duplicate the master curve and produce straight fringes; and there is no need for estimating its value.

The collimating lens system has an infinite variety of shapes. Every different test-plate curvature, diameter, thickness, and refractive index of test plate and auxiliary collimating lens requires a different design.

A steep, convex test plate requires one or more concave surfaces to diverge the rays and form a virtual image of the light source at the center of curvature. The turning point, from a concave to a convex collimator, is found where the radius of the convex test plate is n times the viewing distance, where n equals the refractive index of the test plate. A flat test plate requires a convex back surface to collimate the rays parallel to the optical axis. All concave test plates require one or more convex surface to converge the rays and form a real image of the light source at the center of curvature.

A constant viewing distance is maintained for all work of the same diameter, and it is used in the calculation of the curves for the collimating systems. The usual ratio of viewing distance to diameter of test plate is about six to one for the larger test plates. Ten to one, or longer, is better for the smaller surfaces. The viewing distance is never less than 10", on the smaller surfaces, unless a magnifier is used.

Variation of the viewing distance has some effect upon the reading of the test plate; but the tolerance for errors in collimator design is not very exacting. A greater air space makes greater accuracy necessary. It is most practical to keep the air space to the smallest amount consistent with safety.

It is not necessary to test any of the collimating surfaces for figure; but flaws in the glass are more noticeable than with contact test plates.

McGuire's article will be concluded next month with a discussion of the design of the collimating lens system and of the methods of using the test plates.

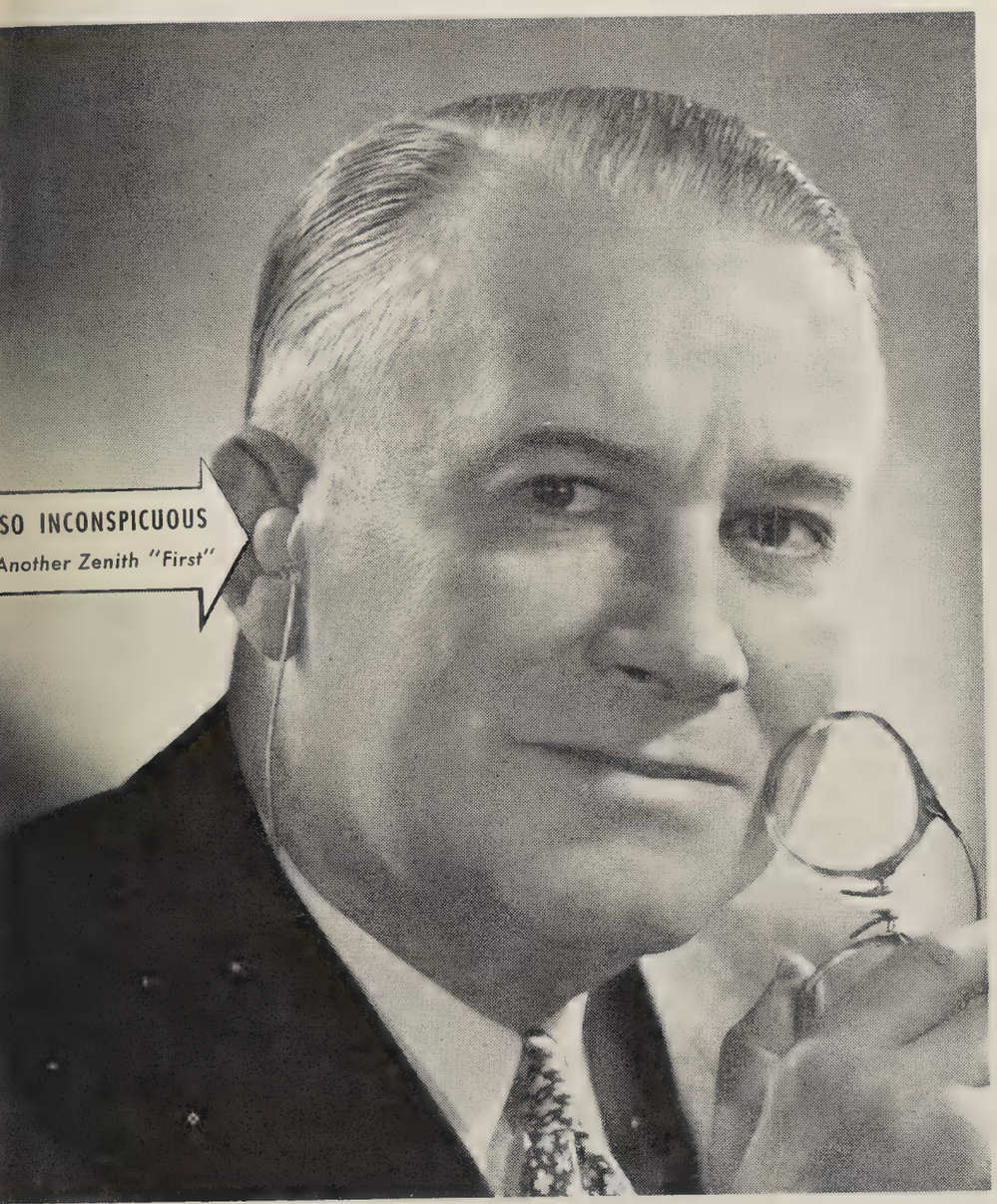
To forestall possible objections that the general method of using separated test plates may have been used in several large precision optical industries for some time, and that McGuire therefore cannot claim it categorically, it is to the point to state that his main contribution is the scotch tape spacers—which, however, in actual shop production greatly speed up the test and therefore the work. You can put the work on the tester, test, remove it and go on working, quickly; so you will test oftener. He contributes something else — the article. It does the public little good to hear that a given method has already been in use in some shop if nobody who is qualified to do so by experience with it takes the trouble to write it up and publish it for the benefiit of others. McGuire has greatly improved the method and he here makes it available, also, to all.

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ONCE AGAIN, a great Zenith advancement is opening up to *new thousands* the joys and advantages of a hearing aid!

First to lower the *cost* of better hearing within reach of all, now Zenith sets a new standard of *smart appearance* that enables you to wear a hearing aid with poise and self-assurance. So inconspicious is Zenith's new Neutral-Color Earphone and Cord that it is actually *as little noticeable as eyeglasses!*

It brings to the hearing aid a new look of youth . . . makes it more popular and casual than ever before.

In place of the old black button, this new ensemble introduces a streamlined, complexion-tinted plastic earphone . . . light, comfortable. Gone, too, is the old black cord—replaced by a translucent plastic cord that is perspiration-proof, fray-proof, kink-proof—gives less friction or clothing noise than any fabric-covered cord.

No longer is there any reason to deprive yourself of an aid to better hearing. Ask the Zenith-franchised dispenser near you for a *free* demonstration of the smart looking, superbly performing Zenith Radionic Hearing Aid. No obligation! Send coupon below for dispenser's name and free literature.

A New Zenith Model for Every Type of Correctable Hearing Loss

1 **Model A-2-A.** New improved model of the famous nationally opular standard Zenith for the erson of average hearing loss. New, patented "Prentiss Tube" rings clarity and volume range ith low battery consumption! Complete, ready to wear, nly $40

2 **Model A-3-A.** New Air Conduction Zenith. A brand new, *super-power* instrument with tremendous volume in reserve to assure maximum clarity and tone quality even under the most difficult conditions! This special model complete, ready to wear, only $50

3 **Model B-3-A.** New Bone-Conduction Zenith. A new, powerful precision instrument created specially for the very few who cannot be helped by any air-conduction aid. Exclusive Zenith "Stator Mount" Headband automatically warns when headband pressure exceeds normal adjustment! Complete, ready to wear, only $50

Why Its Fine Quality Costs You So Little

Like your watch, this hearing aid is a product of precision mass production. If only a few were made, it would cost many times more, be far less accurate—as Zenith proved when it applied precision mass production to lower the cost of a $200 radio to $29 and make it an *even finer* instrument. Now Zenith combines precision mass production with a revolutionary sales method which *eliminates* salesmen's high commissions and other expensive selling costs . . . to bring you at $40 to $50 an *even finer* hearing aid than our original $50,000 model. Remember—Zenith leads the world in precision mass production of Radionic products exclusively.

CANADIANS! The Zenith Radionic Hearing Aid (Air Conduction) with *Neutral-Color Earphone and Cord* is now available in Canada—*direct by mail only*—at $40 (Canadian currency). No extra charge for shipping, duties or taxes! Write Dept. A-10, Zenith Radio Corporation of Canada, Ltd., P. O. Box 30, Windsor, Ontario.

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(All 3 models complete with Radionic Tubes, Crystal Microphone, Magnetic Receiver, Batteries and Battery Case)



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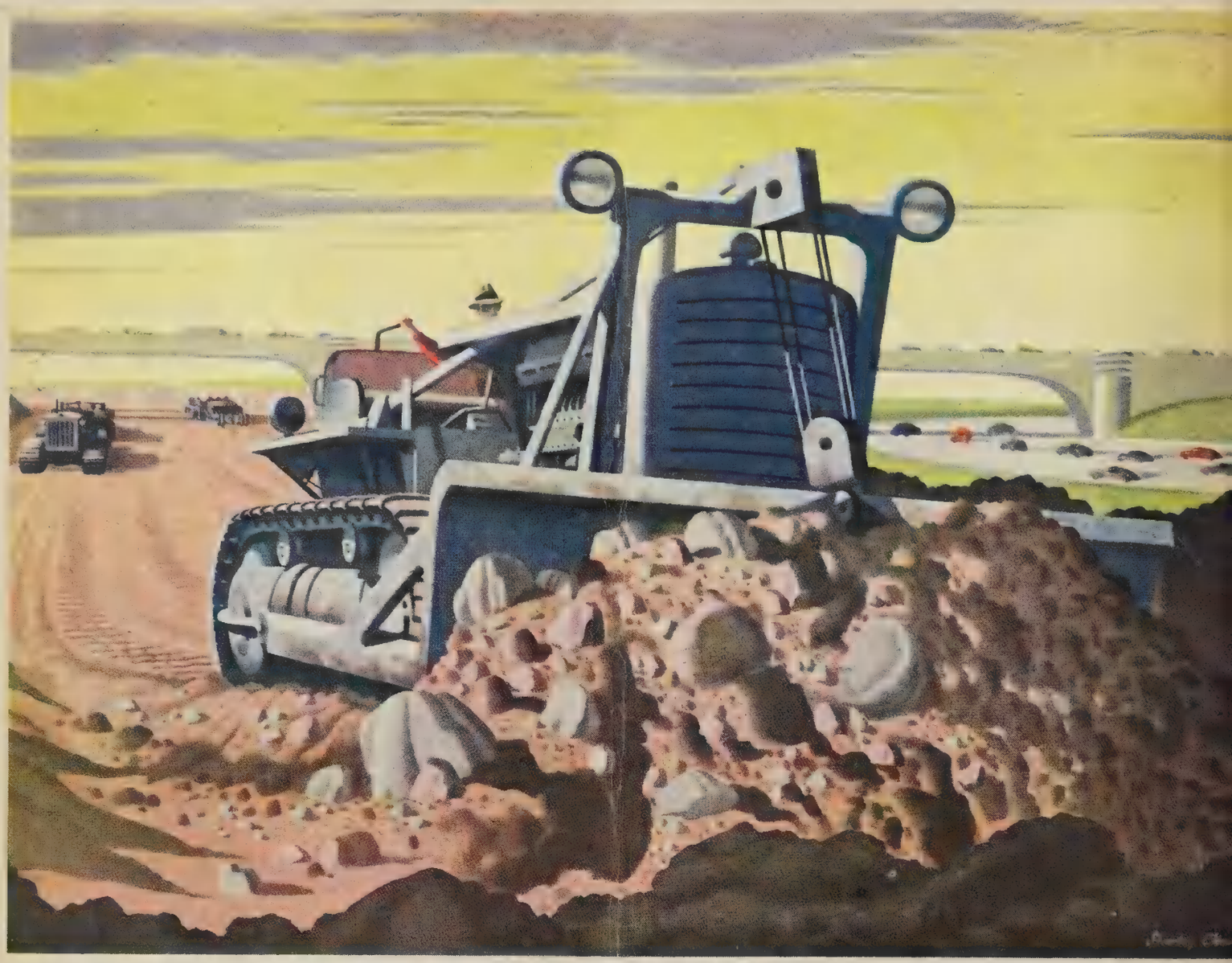
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Finger-tip Control — IN SUPER-HIGHWAY CONSTRUCTION

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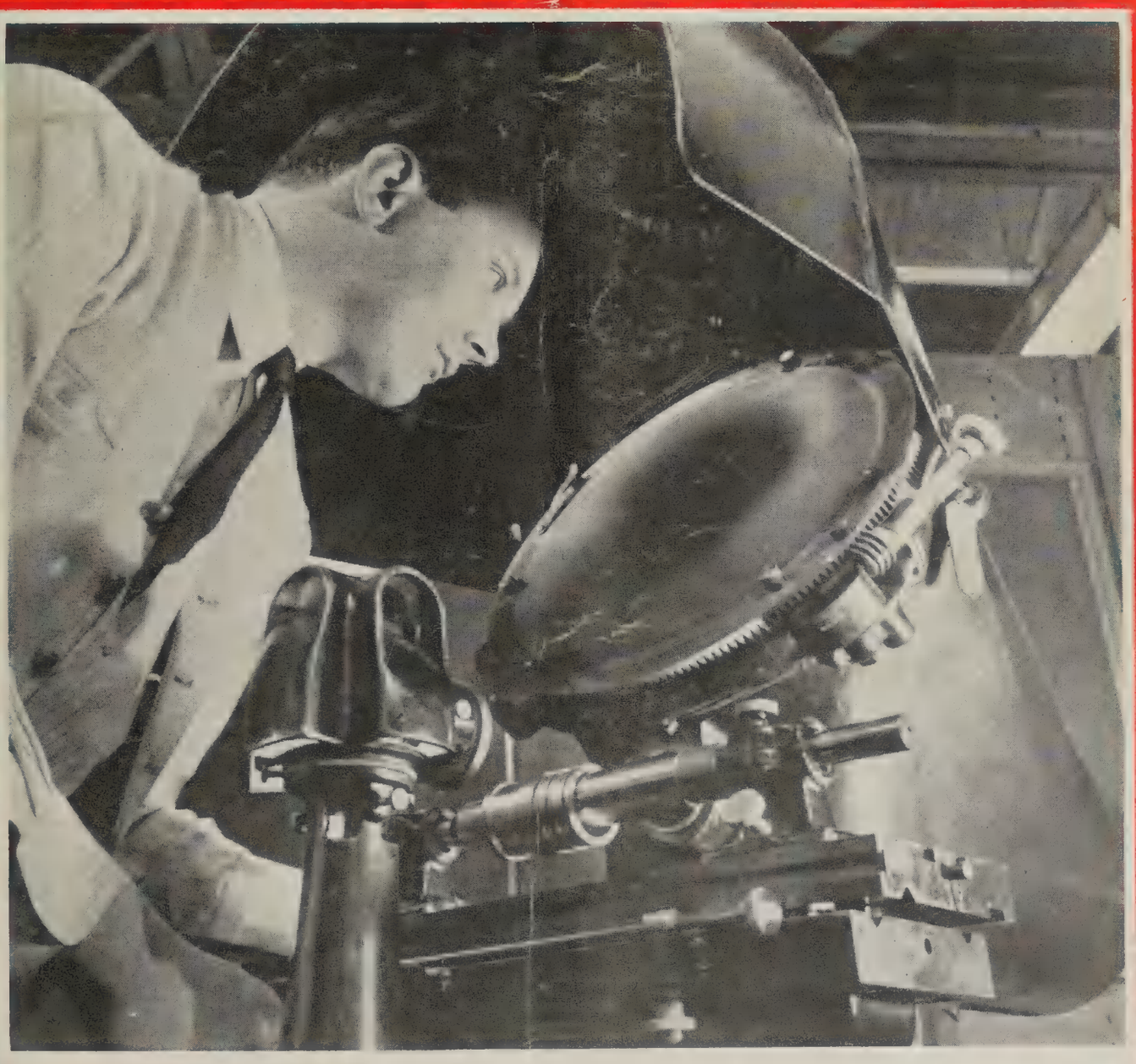
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Scientific American

★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Precision Inspection . . . See page 65

The Story of MECHANICAL ENGINEERING

Anniversary Issue No. 2



The Greeks gave us a word for it . . . now we give it to *you*

WHEN Sperry first developed its velocity-modulated, ultra-high-frequency tube, the word "KLYSTRON" was registered as the name of the new device.

This name — from the Greek, as coined by scientists of Stanford University — is an apt description of the bunching of electrons between spaced grids within the tube.

"Klystron" is a good name. So good, that it has come into widespread use as the handy way to designate *any* tube of its general type, whether a Sperry product or not.

This is perfectly understandable. For the technical description of a Klystron-type tube is unwieldy, whether in written specifications, in conversation, or in instructing members of the Armed Forces in the operation of devices employing such tubes.

These conditions have prompted many requests from standardization agencies—including those of the Army and Navy—for unrestricted use of the name Klystron. In the public interest, Sperry has been glad to comply with these requests . . .

From now on, the name KLYSTRON belongs to the public, and may be used by anyone as the designation for velocity-modulated tubes of any manufacture.

Sperry will, of course, continue to make the many types of Klystrons it now produces, and to develop new ones.

On request, information about Klystrons will be sent, subject to military restrictions.

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Scientific American

Founded 1845

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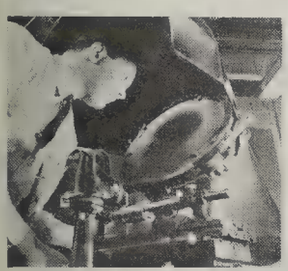
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Our Cover: Precision methods in industry have been largely responsible for many important developments. Our cover picture, used by courtesy of Thompson Products, Inc., shows an optical comparator that aids precision inspection of aircraft parts by throwing greatly enlarged images on a screen.

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Previews of the Industrial Horizon

By A. P. Peck

TECHNOLOGICAL ERAS

FREQUENTLY attempts are made at neatly cataloging differing eras in technological progress, the tags depending upon the interests of the one who attempts to set up the divisions. Latest of these to pass across this desk analyzes the past 80 years in four 20-year periods, assigning them respectively to civil engineering, electrical engineering, mechanical engineering, and chemical engineering.

But such an analysis, which its author admits is oversimplified, loses sight of the complete interdependence of all branches of technology. True, in the early days of this country, at the beginning of the age of rapid transportation as exemplified by the railroads, most spectacular emphasis was on the civil engineer. Behind him, however, was the mechanical engineer—the man who designed the rolling stock—side by side with the metallurgist and the chemist. Often, of course—more often than in the present day of specialization—many of these functions were combined. The point is that through all ages the greatest achievements have been possible only through the greatest coördination of knowledge and effort.

Perhaps World War II has brought home more forcefully the need for this coördination. In any event, there looms on the horizon an era that probably cannot ever be catalogued by any future historian without the coining of some such phrase as "the era of good feeling in technology." This era is foreshadowed in the editorial pages of Scientific American and especially so during the 100th Anniversary Year when each issue presents a feature historical article that gives the background against which to evaluate the present and future.

LITHIUM ON THE WAY

KEEP an eye on lithium and its industrial applications in the near future. One fifth the weight of aluminum, this lightest of all metals is yielding to the probe of research.

Although lithium, in its pure state, has a marked affinity for oxygen and hydrogen, it has long been used in minor ways in metallurgy. Under the demands of war-time needs, production of this metal has been increased many fold and the number of possible applications has jumped almost in like proportion. Today, lithium and its compounds are finding uses in copper castings, tin bronzes and other alloys, as well as in the ceramic, glass and air-conditioning industries.

If the progress of lithium continues, as seems probable at the moment, it will be fortunate indeed that the world's richest deposits are located within the United States.

BETTER BEARINGS

CRANKSHAFT and connecting-rod bearings that will last as long as the rest of the engine are distinct possibilities as a result of Ford experimentation. By using an alloy containing lead, silver, iron, and copper, bearings have been made that show no measurable wear after 50,000 miles of heavy-duty use. Translated into terms of post-war prime-movers of all kinds, this means longer operation between overhauls and, of course, greater efficiency from a dollar-and-cents angle.

SILICONES TOMORROW

STANDING out from the plethora of technological developments of the past year are the silicones, and particularly silicone rubber. (See also page 114.) This rubber, highly resistant to heat, cold, and the deleterious effects of sunlight, will enter tires, printing-ink rollers, chemical processing equipment, even the lowly garden hose. In these applications, and others, it will out-rubber rubber, synthetic or natural. And the silicone resins promise new horizons for the finishes industry, with surface coatings that will come so close to perfection as to leave little to be desired.

PACKAGING IN WAR AND PEACE

DESPITE remarkable developments that have been made in the packaging field to meet military requirements and to circumvent materials shortages, some new packaging methods will face tough sledding when normal times return. Many pliable packages have been perfected as containers for all kinds of materials, both liquid and solid. These packages are doing a splendid job on battle-fronts and in civilian markets alike. But they lack the eye-appeal, the substantial feeling, of the containers to which people have become accustomed during the past couple of generations.

Several manufacturers of consumer goods have already stated that they will go back to the familiar tin cans and boxes just as soon as possible. This they will do regardless of the fact that completely satisfactory containers of pliable materials will cost much less. The manufacturers base their reasoning on the irrefutable logic that post-war competition is going to be greater than ever before and that the package which will sell the most goods is the one to use. If the public will not accept containers that look like "a brown paper bag," and will accept cans and boxes, much of the war-developed technology of packaging will go out the window.

THREAD DESIGN

THE LOSS in hours and dollars that has been brought about by differing standards of machine-screw threads is tremendous. American and British ordnance parts are not interchangeable even though the completed products are of identical design. And the lowly screw thread is the reason. Because there has never been international standardization of these important mechanical elements, many phases of military production and repair have been sadly delayed.

The same thing can and has happened in civilian life. Because of variations in thread design, many a machine has been laid up for weeks while waiting for a special screw with which to make a repair that takes only minutes.

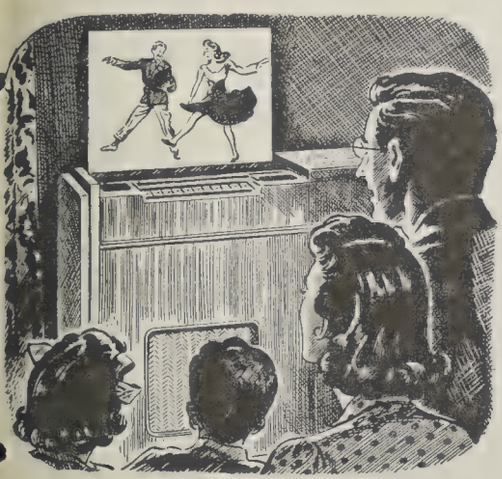
Here is one of those industrial problems that should be tackled. It is a post-war job that should not be laid away in moth-balls and forgotten.

FOR FUTURE REFERENCE

BAGASSE, sugar-cane by-product available in huge quantities, is a potential paper-making material . . . In a new design for cargo planes of the "tractor-trailer" type, the cargo section of the fuselage is detachable for loading while the rest of the plane is flying another load . . . Sheet iron and steel, hot-dipped in aluminum, comes out with all the appearance of the light metal, but is less expensive than an equal thickness of aluminum; it will have applications where surface characteristics of aluminum are desired yet added weight is not objectionable . . . Rayon has proved itself so completely in heavy-duty truck tires that its post-war use is a certainty . . . Your next radio set may be equipped with a simple time dial, controlling an electric motor, that will make it possible to preselect the time at which the receiver will be turned on automatically.

General Electric answers your questions about

TELEVISION



Q. What will sets cost after the war?
A. It is expected that set prices will begin around $200, unless there are unforeseen changes in manufacturing costs. Higher priced models will also receive regular radio programs, and in addition FM and international shortwave programs. Perhaps larger and more expensive sets will include built-in phonographs with automatic record changers.



Q. How big will television pictures be?
A. Even small television sets will probably have screens about 8 by 10 inches. (That's as big as the finest of pre-war sets.) In more expensive television sets, screens will be as large as 18 by 24 inches. Some sets may project pictures on the wall like home movies. Naturally, pictures will be even clearer than those produced by pre-war sets.



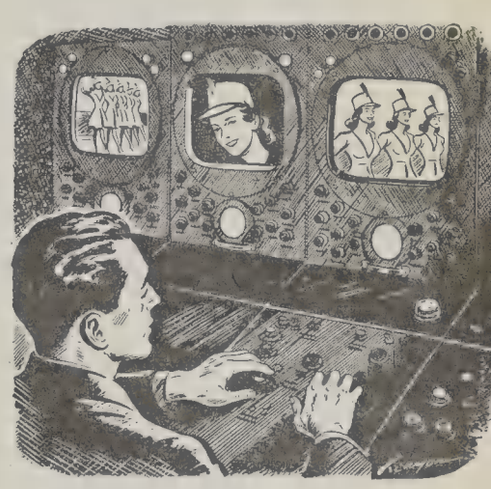
Q. What kind of shows will we see?
A. All kinds. For example: (1) Studio stage shows—dancers, vaudeville, plays, opera, musicians, famous people. (2) Movies can be broadcast to you by television. (3) On-the-spot pick-up of sports events, parades, news happenings. G.E. has already produced over 900 television shows over its station, WRGB in Schenectady.



Q. Where can television be seen now?
A. Nine television stations are operating today—in Chicago, Los Angeles, New York, Philadelphia, and Schenectady. Twenty-two million people—about one-fifth of all who enjoy electric service—live in areas served by these stations. Applications for more than 80 new television stations have been filed with the Federal Communications Commission.



Q. Will there be television networks?
A. Because television waves are practically limited by the horizon, networks will be accomplished by relay stations connecting large cities. General Electric set up the first network five years ago, and has developed new tubes that make relaying practical. G-E station WRGB, since 1939, has been a laboratory for engineering and programming.



Q. What is G. E.'s part in television?
A. Back in 1928, a General Electric engineer, Dr. E. F. W. Alexanderson, gave the first public demonstration. Before the war, G. E. was manufacturing both television transmitters and home receivers. It will again build both after Victory. Should you visit Schenectady, you are invited to WRGB's studio to see a television show put on the air.

TELEVISION, another example of G-E research

Developments by General Electric scientists and engineers, working for our armed forces in such new fields as electronics, of which television is an example, will help to bring you new products and services in the peace years to follow. *General Electric Company, Schenectady, N. Y.*

Hear the General Electric radio program: "The G-E All-Girl Orchestra," Sunday 10 p.m. EWT, NBC—"The World Today" news, every weekday 6:45 p.m. EWT, CBS.

GENERAL ELECTRIC

952-629-2

FOR VICTORY BUY AND HOLD WAR BONDS

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of February, 1895)

ENGINEERING — "The profession of a mechanical engineer, to the uninitiated, holds forth big inducements, and the young man who starts in college works his way along, graduates, and nine cases in ten is assigned a position over the drawing board. Draughting, in its higher forms, is one of the most interesting subjects in existence, especially when other conditions are such as to promote the interest. It rests in the hands of the draughtsman whether the machine will be pulled down several times in order to correct mistakes, and in many cases whether the machine goes to the 'scrap heap' or is shipped away a success."

BICYCLE LIGHTS — "Among the [new bicycle] lanterns are two classes of electrical ones. One is supplied by a dynamo driven from a friction wheel bearing against one of the tires; the other is provided with a battery."

WOOL CLEANING — "In a new method of scouring wool, naphtha is employed as the cleansing substance. By means of a pump the naphtha is forced through and through the wool, extracting all the natural oil. It is claimed that the naphtha does not injure the fiber of the wool, as alkali cleansing, but leaves the fleece in better condition than when cleansed by any other process."

AIR CONDITIONING — "It must be something like fifteen years since the air of the Madison Square Theater was artificially cooled in the summer by passing it over ice; and refrigerating apparatus is in use in every large city in the civilized world, for cooling rooms for the storage of provisions. Many attempts have been made to introduce refrigerating apparatus of the same sort as that used in the cold storage buildings into dwelling houses, but they have failed to please the public."

ACETYLENE — "A chance of putting acetylene to a practical use is afforded by the growing need in many places and for numerous purposes, of a self-contained source of gas of high illuminating power. The bare fact that a portable solid substance can be caused to generate a gas of the required quality by mere contact with a sufficiency of water suggests numerous applications of this order."

RUBBER TIRES — "An experiment has been made recently in New York of much importance concerning the relative value of rubber-tired wheels on ambulances. . . It has not as yet, however, been determined whether the solid or the pneumatic tires are preferable. . . Several inconveniences have been experienced in the use of both forms of rubbr tires. The ambulances are so heavy that the pneumatic tires collapse very often. And the solid tires are likely at any moment to be torn from the wheels, since the strain is unusually great. These difficulties, it is thought, however, can be remedied in time."

SEA SALT — "Extensive works have recently been established at Oldbury, near Birmingham, for the electrolytic preparation of chlorine and caustic soda from sea salt. . . The establishment contains 30 pans, which permit of the daily production of 1,300 pounds of caustic soda and 1,100 of liquid chlorine."

DANGEROUS ARCS — "Over the street doors of one of our most extensively patronized dry goods stores arc lights are suspended for purposes of illumination. Throngs of ladies are constantly passing to and fro under these lights. We noticed a narrow escape for a lady the other evening. Fire fell from the arc lamp and just grazed her dress as she passed under the lamp. The inflammable nature of women's apparel is such as to render it dangerous for them to stand or pass under arc lights. There should be a law to prohibit the use of open arc lights. It would be easy to arrange a glass basin or plate under the lamp to catch and arrest any falling bits of the ignited carbon."

JET PROPULSION — "Instead of the ordinary screw propeller, jets of water are used to drive a new steam-propelled lifeboat. The water jets are produced by means of rotary pumps, and when the jets are discharged from the stern the boat is driven forward. The discharge nozzles are capable of being shifted, so as to direct the jets laterally, in which case the vessel may be turned around or made to move sidewise."

OIL BURNING — "Hundreds of patents have been secured for different methods of spraying and burning liquid fuel. The great secret of success seems to lie in so arranging matters that the flame will not burn itself out and prevent the oil from being properly consumed."

RAIL WELDING — "The electric welding of railway rail joints has, from its inception, attracted the especial attention of street railway managers, particularly those operating trolley lines. In the accompanying illustration we present another method of welding rail joints, recently brought forward by the Falk Manufacturing Company, of Milwaukee. It consists in casting around the meeting ends of the rails, in heated metal moulds, a large body of melted iron, the principal portion of the metal being directed about the base and web of the rails, and thus effecting, it is claimed, a good weld between the iron and steel of the rail."



Rail joint cast-welding outfit ready for work

BLAST FURNACES — "The number of blast furnaces in activity in the United States at the commencement of November, 1894, was 181, their aggregate weekly productive capacity being 158,866 tons. The corresponding number of furnaces in operation at the commencement of August, 1894, was 135, their aggregate weekly productive capacity being 115,356 tons."

TYPEWRITER RIBBONS — "The manufacture of ribbons for typewriting machines is an industry which gives employment to a large number of people. On nearly all the first-class typewriters these inked ribbons are used. There are at least forty different styles of American typewriters, and more than 400,000 machines are in actual use. . . Each manufacturer has a secret process for making his particular style of ribbon, and the secret is guarded with the greatest possible care."

FUTURE FOOD — "According to Professor Berthelot, the distinguished French chemist, the time may be approaching when the farmer will go out of business, and bread and beef and milk, or their equivalents, will be produced artificially in the laboratory of the chemist."



A MICA MINE
IN A LABORATORY

War shortages crop up in strange materials. Mica, for instance. Once seen principally in the windows of stoves, and in small boys' pockets, it is now used extensively as electrical insulation. In some war products, it is virtually indispensable: capacitors for radio, spark-plugs for airplane engines, insulators in electronic tubes.

With demand mounting, manufacturers were desperate. A four-man technical mission flew to London to help ration the world's supply between the United States and Great Britain. The shortage was serious.

The War Production Board, convinced that much mica was classified too low when judged by appearance alone, asked Bell Telephone Laboratories to develop a new method of electrical tests. The Laboratories were able to do this quickly and successfully because of their basic knowledge an experience in this field.

The new tests were made availab to manufacturers in this country an abroad—the supply of usable mica wa increased 60% — and a difficult situ tion relieved.

Skill to do this and other war jo is at hand in Bell Laboratories becaus year after year, the Laboratories hav been at work for the Bell System.

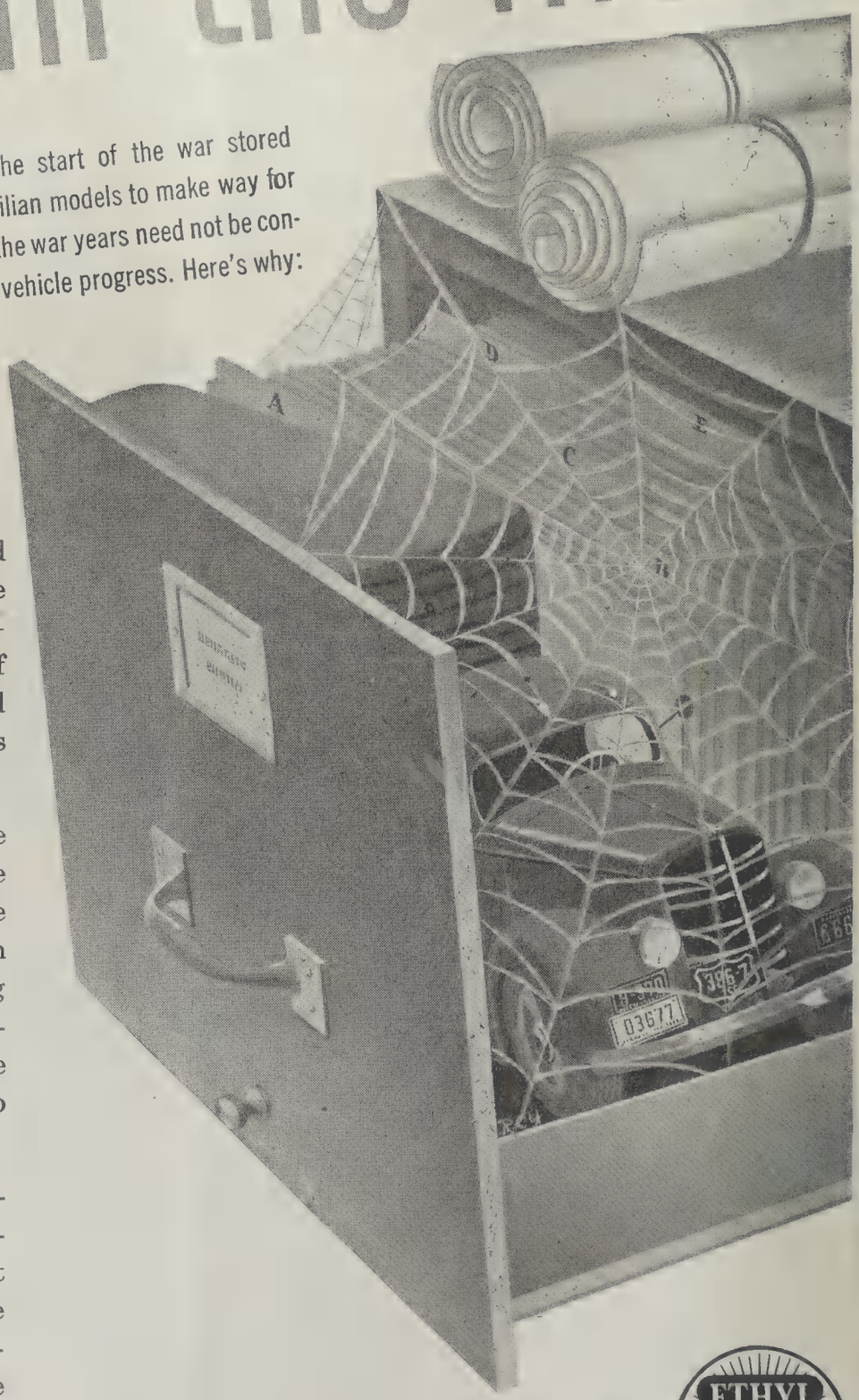
BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in telephone servic

ALL COMMERCIAL CAR PROGRESS WASN'T

stuck in the files

Truck and bus manufacturers at the start of the war stored away designs and ideas for new civilian models to make way for production of military vehicles. But the war years need not be considered lost in terms of commercial vehicle progress. Here's why:



The engine of a motor truck or bus and the gasoline that powers it are not separate things, but are two parts of a single unit—power for motor transportation. Thus, if the antiknock value of gasoline is improved and engines can take advantage of this improvement—progress has been made.

The requirement for aviation gasoline for the war effort has necessitated the building of a tremendous capacity for the production of high octane fuels. Although at the present time this equipment is being used exclusively for the production of aviation fuel, it is readily adaptable to the production of motor fuels far superior to those marketed in the pre-war period.

Immediately after the war the petroleum industry will be able to supply gasoline of far higher quality . . . gasoline that in engines designed to utilize it will give more power, more mileage, better performance. Thus, the foundation for more efficient engines is already laid.

ETHYL CORPORATION

Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.

ETHYL — BRAND OF ANTIKNOCK COMPOUND — ETHYL CORPORATION — TRADE MARK REG. U.S. PAT. OFF.



Wartime progress by America's petroleum industry has paved the way for fundamental progress in post-war automobile engine design.

Scientific American
FEBRUARY · 1945

★ 100th Anniversary Year ★



An installation, in 1880, of Babcock and Wilcox boilers in a Standard Oil refinery

A Century Of Engineering

By EDWIN LAIRD CADY

By Reviewing the History of Mechanical Engineering and Its Effects on the Industrial Era of Today, a Background is Established Against Which Many of the Possibilities of the Future Can Be Evaluated

IT WAS NO mechanical wilderness into which Scientific American was born in 1845. In fact, power and the machinery with which to use it—the main concerns of the mechanical engineer—had advanced far enough so there was real need for a magazine devoted to the progress of science in industry.

The steam engine, invented by James Watt in 1769, was 76 years or four mechanical generations old. It was hauling trains in England and the United States. Oliver Evans (1790) had built high-pressure steam engines in Philadelphia. Fulton had proved his steamboat (1807), and the world had decided that it was not the man who first thought of an idea, as had Evans and Fitch before Fulton, but the one who made it useful to the world, who was to be credited with it. This was important because in that era hundreds of mechanical advances were being kept secret and no one will ever be sure who first developed them.

The first Baldwin locomotives were being built in 1832. In 1823 the French Government had determined the temperature and many of the properties of steam up to 350 pounds pressure, and "dry" steam techniques were on their way. By 1840 every type of fire-tube boiler was in use.

TURBINES—Power as a by-product of other processes was known in 1838; the flame-ignition gas engine was running on waste gases. The principle of the steam turbine was well known; it was regarded as interesting but impractical. On the other hand, inventors worked day and night on the gas turbine.

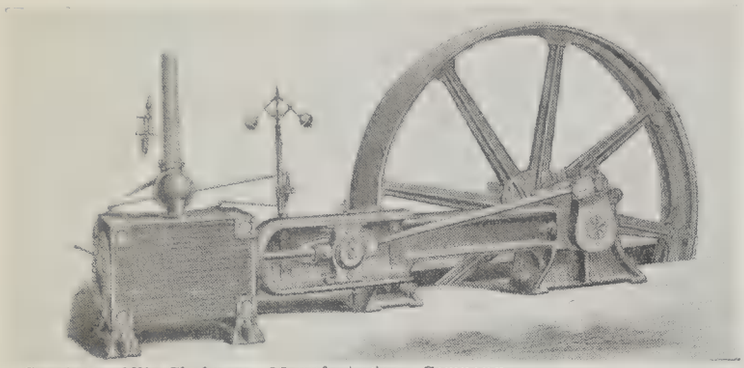
Electrical power had made something of a start. Faraday (1821) had converted electrical current into mechanical motion. Sturgeon's rotary electric motor (1832), Jacobi's electrically propelled boat (1839), a five-ton electric locomotive in Aberdeen, Scotland, (1839), and Morse's telegraph (1837) were showing how electricity could be made useful to mechanical engineering.

Water wheels were the main source of mechanical power as they had been for thousands of years. But the 30 percent efficient under-shot wheel was being displaced by the 60 percent efficient over-shot and the 70 percent efficient breast wheel. Impulse turbines (1835) made high falls of small streams useful. Fourneyman had a six-horsepower water turbine in 1827, a 50-horsepower one in 1832. And with the formation of the Escher-Wyss company in Switzerland in 1845 the modern science of water power was well on its way. This company was the real developer of the turbine.

POWER TRANSMISSION—Prime movers, indeed, were much farther advanced than the means for transmitting the power they generated. *The Journal of The Franklin Institute* (1837)

described fully integrated belt-driven cotton mills in Lowell, Massachusetts, belying the belief that modern belt drives originated in the 1780s. Infinitely variable ratios, within limits, had been created in an opposed-cones belted device of a type still in wide use. In 1786 the Watt and Boulton flour mill (England) had been built with the then unheard-of metal shafts and bearings. A few slow-speed chain drives existed. Babbit metal was invented in 1839.

Gears were the mainstays of power transmission. Most of these were cast, although many were made of metal strips



Courtesy Allis-Chalmers Manufacturing Company

In 1878 the Allis Company offered to the waiting public an improved Reynolds-Corliss engine. This type marked a step forward in supplying industry with better power and higher speeds. Within the next 25 years, 6000 of these improved engines were made

fastened across the rims of wooden wheels. They made a horrible racket when they ran, but then the mechanic of that day was as proud of the distance at which his factory could be heard as of the rancid lard or sperm-oil smell which permeated his hair and clothing and advertised his calling to all who passed him on the street.

Any refinements in power transmission were built into individual machines; they seldom were found throughout any shop as a whole. Thus the machine shop of the day had lathes complete with lead screws, sliding rests, and change gears. Bevel gears were known in 1775, the involute form of gear tooth in 1760. Sometime around 1800 Oliver Evans of Philadelphia had a machine to cut involute gear teeth

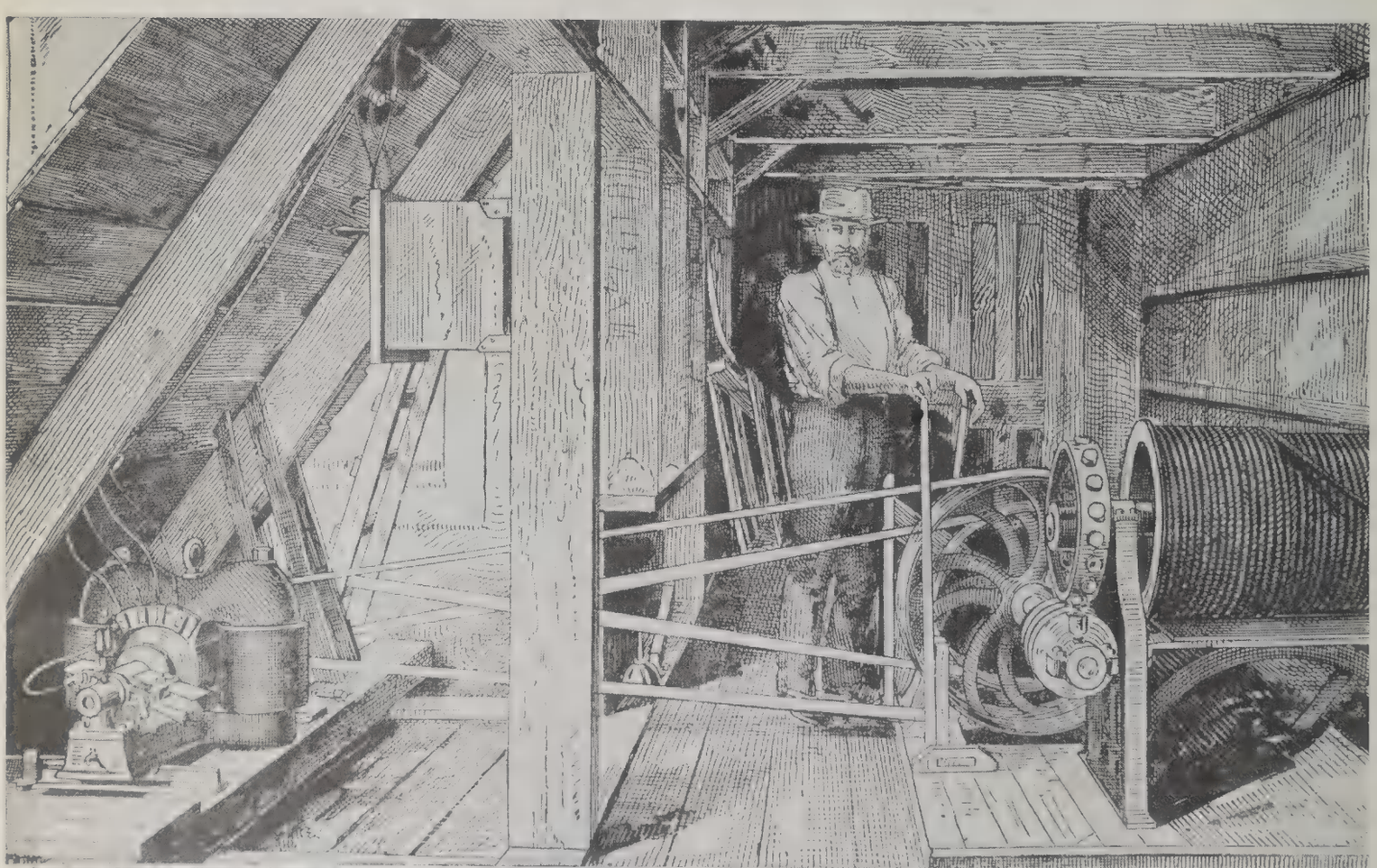


William Dana Ewart demonstrating his invention, the detachable-link chain, preceding the organization of the company that grew into Link-Belt Company

accurate to shape, diameter, and pitch line, but nevertheless the Saxton (Philadelphia, 1837) accurate gear-cutting machine was a wonder of the world. The Putnam lathe (Massachusetts, 1835) had back gearing with worm and rack feeds, and the Baxter D. Whitney lathe (Massachusetts, 1833), had worm wheels and a four-step cone pulley.

Machine tools, as usual, were far more advanced than the machines which were to be made upon them. Shops had engine lathes, planers, shapers, drill presses, and boring mills. The steam hammer was at work. Eli Whitney, making rifles, was using special machines for forging, rolling, boring, grinding, and polishing. Terry had made wooden clock wheels on a mass-production basis, then had switched to brass and was stamping them. Stamping operations to put heads on pins had been known since 1680, and the micrometer principle of measuring since 1637. Eli Whitney had made the first milling cutter in 1818. And milling was to remain a peculiarly American method until well after the Civil War. Failure of the Europeans to adopt it to any great extent gave American industry enormous advantages in the production of twist drills, gears, splines, and all sorts of form-cut parts.

The first Fairbanks platform scale (tap root of Fairbanks-



Courtesy General Electric Company

A Sprague electric motor operating a hoist in the 1880's

Morse) was made in 1830. There was nothing like it in the world. It was a first step in accurate control of production.

THE AMERICAN WAY—Most important in the scene to which Scientific American was born, was that the "American Way" of mass production and integration was already well established.

This way started with the very colonies. By 1650 America had over 2500 saw mills—the lumber industry was integrated. Europeans tried every possible trick to prevent us from learning how to manufacture. Sand castings took the place of loam molds (1708), spinning machinery was developed in 1738, the Jacquard loom—still one of the most amazing automatic machines—was invented in 1801, and the only way we could get any of these machines was literally to sneak the men who knew the secrets into our country. From these experiences we got the habits of learning all we could by any means we could, integrating all the knowledge we obtained, and thinking for ourselves.

Development of interchangeability in musket making (Whitney, 1798) was a natural evolution of integration. Eli Terry's clocks (1803), Colt's revolvers (1836), and the equally great contemporary work of Simeon North followed. In another line, Oliver Evans (1783) fathered materials handling; he had bucket elevators, chain and drag conveyors,



An early Fairbanks platform scale. These weighing units made possible the first steps in providing accurate quantitative control of industrial production

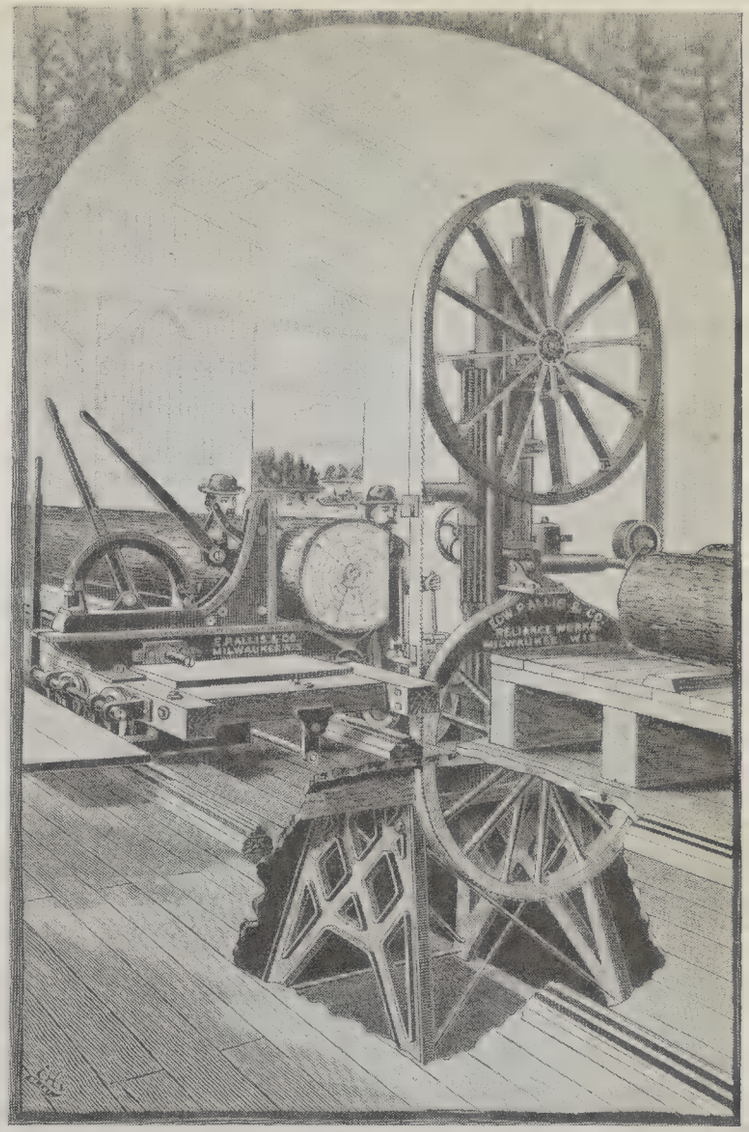
screw or helicoid conveyors, cleated belt and bucket belt conveyors. We never have departed from these methods. For over 100 years the Europeans, and principally the English, have called them the "American System."

By 1820, Pawtucket, Rhode Island, was a flourishing machinery center. Large machinery enterprises were on their way all over the land. Colonel Stephen Jenks (1820) started the nut and screw company which was to become the William H. Haskell Company. Some forebears of other great companies: 1838, the Eagle Screw Company which became the American Screw Company; 1833, the forerunners of Brown and Sharpe; in 1839 Russell and Erwin were making hardware in New Britain, Connecticut; and in the 1830s the company was started which was to end up as Jones and Lamson.

Paul Revere had rolled copper in 1801; Scovill, at Waterbury, invented the brass and copper utensil spinning process in the 1830s, and Waterbury was a flourishing copper center.

Not everything was in the east. Flour milling started in Wisconsin in 1835. The real beginning of Allis Chalmers was in Milwaukee in 1847. Circular saws, used in Maine in 1824, were to spread quickly to the Great Lakes lumber regions.

Scientific American, then, was born into a nation which badly needed a periodical to integrate its integration-minded



From the first successful American band-saw mill built in 1869, this type developed to the refined form shown, manufactured by Edw. P. Allis and Company, after George M. Hinkley's design, in 1885

industrial men. And the fact that this same integration-mindedness has dominated nearly all the American scientific and industrial magazines, has made them the greatest and most useful the world has ever known.

TWENTY FORMATIVE YEARS—Historical periods cannot be defined to the point of strait-jacketing their implications. Descriptive labels of periods must be preceded by an understood "generally speaking." And, generally speaking, the years 1845-1865 were a formative period in mechanical engineering.

Power production made some long jumps. Regnault worked out the principles of superheated steam (1847), and two years later the relation of heat to power was found at 772 foot-pounds per BTU: it now is known to be 778. By 1859 Rankine had developed the theories of steam expansion, condensation, and re-expansion in the steam engine cylinder. Surface and jet condensers both were in use in the 1850s. Richards steam engine indicator (1860s), was the first one good enough for high-speed engines.

Bourdon's pressure gage and the Corliss steam engine both arrived in 1849. And with Henri Giffard's injector feeder (1859), steam was ready for advanced reciprocating engines and for turbines.

Centrifugal pumps (1850) initiated the high RPM age in power, but nobody knew it at the time. Worthington's huge pumps, first made in the 1840s, were to dominate pump rooms for decades to come.

Out in gold-rushed California the spoon-shaped bucket impulse water turbine was dreamed-out by a miner who let his old style wheel wear until the buckets were slightly to one side of the main force of the stream. He found that the wheel worked better that way, and changed the buckets (1854) to take advantage of this.

Another development was made by men who little realized what they were starting. Beau de Rochas, a mathema-

tician, worked out the four-cycle principle of the gas engine, and Otto (1860), made a "silent" four-cycle engine which worked.

Power transmission was to get its real start. In 1845 the Hope Cotton Factory (Pittsburgh) was secretly lubricating its machines with a mud-colored, greasy fluid which came up in Lewis Peterson's salt well, and petroleum lubrication had begun. Mineral oil was found in large quantities in 1859, and by 1855 enough engineers had learned of Hope Mill's use of it so that the world was ready. In the meantime the "oilless" bearings had arrived; Yankees were making bearings of lignum vitae and lubricating them with water.

BIRTH OF THE MODERN FACTORY—Most important to power transmission, James Coombs of Belfast, Ireland, worked out a rope drive (1856) with the endless ropes—a rope is easy to splice endless—working in V-grooved pulleys. The "American Rope Drive" soon followed. Here was the big difference. Coombs used a main shaft but ran a single rope to each machine. The Americans used a single rope from a main drive pulley and ran it to all the machines, thus integrating whole factories so that the machines in sequences could not



Bustles, coat-tails, and derbies had their place in industry in the 1880's, along with mazes of power-transmission belts, as witness this scene in the wire-insulating department of General Electric

get out of time with each other. With the Coombs selective as well as the American integrated drive ready, power transmission was freed from the short center and limited space problems of gears, but could have the advantages of gears also. The modern factory was here.

The first American machine-made wire rope (1846) presaged modern mining methods, materials handling, and elevators.

Steady flowing power, which did not fluctuate with the heights of streams, was more and more necessary. Mass production was coming along. The Hoe revolving printing press (1845) needed it. The Howe sewing machine (1846) could be cheap enough for public use only if mass made. Aaron L. Dennison of Boston was making machine-made stem-winding watches in 1850. The English confiscated the first lot he shipped them but paid the declared value price; they thought he was dumping his watches, but when he gleefully sent over a much larger lot, and then a third still larger one to this quick cash market, the customs officers called it quits and let them go on to the wholesalers. In 1856 Brown and Sharpe standardized the wire gage. After that, American clock springs and other wire goods were nationally standardized and mass production was nationally integrated on its first item.

PRECISION PRODUCTION—Machine tools and measuring instruments were of mass-production types. Stephen Fitch, of Middlefield, Connecticut, had a horizontal turret lathe with eight tool positions in 1845. J. R. Palmer (1848) had a workable micrometer caliper. Automatic gear cutting ma-



The still famous Stillson wrench has changed but little from this original design patented in 1870

chines (1850s) and a gear cutter with an index plate having 15,690 holes (1852), were followed by the first Brown and Sharpe precision gear cutter in 1855.

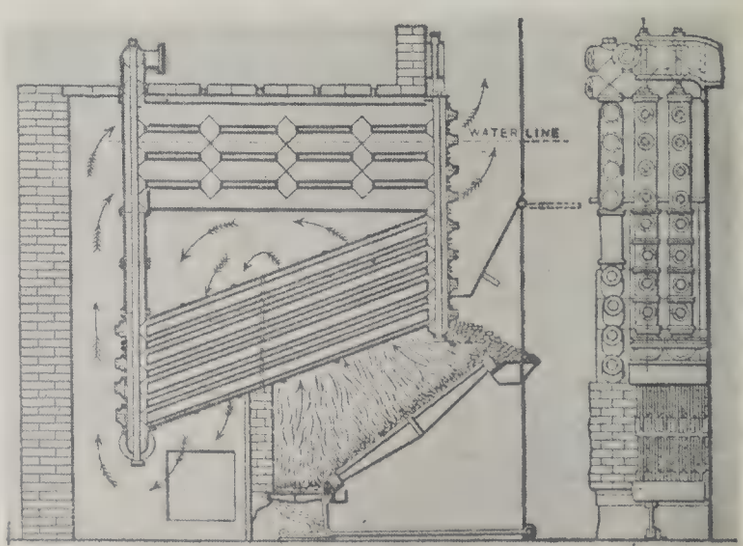
In 1851 Brown and Sharpe brought out a vernier caliper accurate within thousandths of an inch; they followed it with a similarly accurate vernier protractor the next year.

E. K. Root developed a chucking lathe (1855) at Colt's Armory. 1861 saw the start of Pratt and Whitney. In 1861 Brown and Sharpe announced the first universal milling machine and the first automatic screw machine—either would have been a mechanical engineering milestone. The first commercial grinding machine, the Brown and Sharpe cylinder grinder, followed in 1864. In that same year Sellers (American) internationally standardized the micrometer at 60 degree thread angle, and Brown and Sharpe brought out the first spiral miller for cutting grooves in twist drills and the first formed milling cutter which kept its accuracy through several sharpenings. None of these devices had much meaning unless used for mass production—the "American System."

Other events showed how the mechanized age was rapidly growing. Among them were the gimlet pointed wood screw (1846); the first cable car (1858); the birth of refrigerating machinery (1860s); hydraulic presses (1860s); and the first Otis passenger elevator in 1861.

THE EXPLOSIVE SEVENTIES—In the early 1860s, industry seemed fixed in its character. Factories had to work long hours. Their slow acting fire-tube boilers were hard to get up to the production steaming point, and would not stand heavy fluctuations in the load. Water power was available only during the seasons when the streams supplied it, and the plants had to run as long as they could while they had it. Men, in short, were servants of stupid monsters known as power plants, and there was many a social philosopher to remind them of it. Worst of all, this condition threatened to continue until it engulfed all civilized mankind.

About 1865, industry began blasting itself free of these



A drawing of the original Babcock and Wilcox boiler which brought flexibility to steam power plants



This Worthington pumping engine (capacity six million gallons per day) was built in 1876

restrictions. It was the 15-year era of the "explosive seventies."

The first Babcock and Wilcox boiler, with its inclined water tubes, its headers and drums (1867), meant quick steaming. Now power could be had quickly and the load could fluctuate widely. Plants powered by steam could be flexible, adaptable.

Feed-water heating was born in 1870. It was economical; power cost was reduced and therefore more power could be used; it made fluctuating loads much easier to handle—steam can be raised far more easily from hot water than from cold.

The Brotherhood radial steam engine (1870) substituted the unheard-of speed of 225 RPM for the 20 to 60 RPM engines then in common use. It did away with 20 foot diameter fly wheels, the 1800 square feet of floor space devoted to the engine alone, and so on, which were needed by the slow acting engines. It joined the centrifugal pump in using high RPM to get rid of bulk.

Most important of all, Moses G. Farmer took out the first American patent on a dynamo in 1875. Thompson, Brush (General Electric), and others were only a year or so behind him. Industry was about to receive the flexibility which only the electric motor could give it.



In this crude electric furnace, Dr. Edward Goodrich Acheson conducted experiments in the 1890's in the production of the now widely used Carborundum

FLEXIBLE POWER—Power transmission had arrived. The shifted belt, the friction clutch, and the jack shaft (counter shaft) were adding to the flexibility of operations. Rawhide pulleys and paper pulleys as well as leather covered iron ones were permitting more power to be transmitted by smaller equipment. Cotton belts impregnated with rubber were used for wet conditions, but no one then foresaw the modern rubber belt. The disadvantages of lard oil as an all-purpose lubricant were quite apparent. One English manufacturer was distilling 400,000 gallons of lubricating oil a year from coal. Ewart (1874) made the first successful detachable link chain; this was the start of the Link Belt Company and also of modern chain drives.

Westinghouse's development of the air brake (1869), following hard on the heels of 3000-foot pipe lines to take compressed air to rock drills in Italy, got modern compressed-air methods well under way. The adaptability of this method of power transmission still solves thousands of factory problems.

Accurate ball bearings were first announced in 1877. The handicaps of friction in power transmission were on their way out.

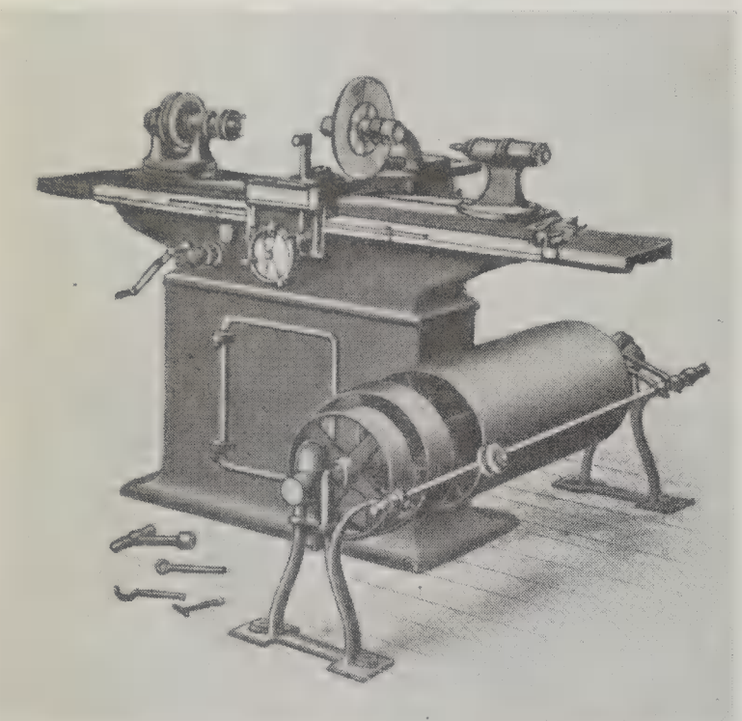
AGE OF ACCURACY—Machine shop equipment came on rapidly. In 1867 Brown and Sharpe had a sheet-metal micrometer accurate to .001 inch, and in 1877 a micrometer caliper good enough to free the tool maker from the need of making his own measuring instruments. Professor Rogers of Pratt and Whitney worked out the Rogers Bond Comparator and found most standard measuring blocks faulty

He persuaded France, England, and the United States to build standard meters, yards, and inches which were really accurate. International standards good enough to build world trade by integrating all the industry of the world were on their way.

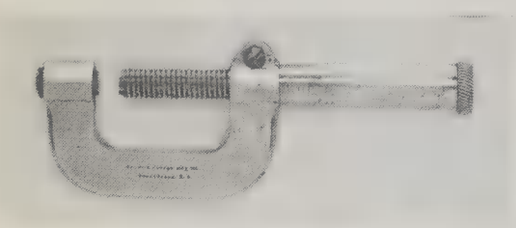
Billings and Spencer (1869), greatest developer of drop forging, was founded in Hartford. Spencer (1870s) worked out the first strap cam controlled automatic screw machine.

The first vitrified grinding wheels were made in the Norton Pottery Plant in Worcester, Massachusetts, in 1873. 1876 saw the first Brown and Sharpe universal grinder. The age of accuracy was developing rapidly.

Band saws appeared in the lumber industry in 1869. Cheap steel (about 1870) removed many of the handicaps from machine builders. Emerson (1875) erected a testing flume at Holyoke, Massachusetts, to test water wheels under standard conditions; hundreds of models were sent to him and standard testing got under way. Cigarette machinery (1876), Remington typewriters (1878), and, most of all, the National Cash Register (1879), were the foundation stones of modern mass marketing. With the first Ingersoll compressed air rock drill (1871) Ingersoll Rand was born and with it the modern age of road building. In every direction, industry was finding new fields for itself.



The original universal grinding machine, made by Brown and Sharpe. Such machines as these, developed in the last half of the 1800's, were ideally adapted to pushing forward the "American System"



This Brown and Sharpe micrometer caliper was first listed in an 1877 catalog

THE INTEGRATION DECADES—At the beginning of the 1880-1900 period, hundreds of mechanical devices had been tried only on a small scale, and hundreds of others had been so localized in their use that their relation to each other was none too apparent. If our modern age of mass production was to grow up, there had to be an age of integration coupled with further development. The "American System" of mass production and marketing had to take form.

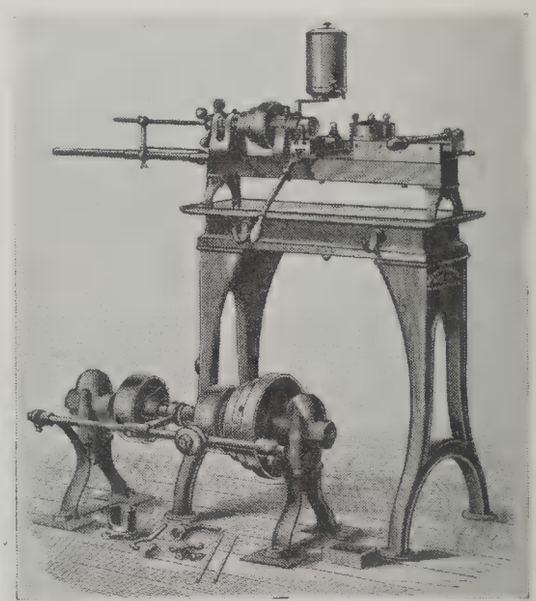
Frederick W. Taylor began his efficiency-engineering work in 1880. First, he worked out his work-rest-work method and proved how much more the human body could do if integrated to a task. Then he directed a heavy stream of water on a cutting tool and found that the speed of the machine tool could be increased 30 to 40 percent when the tool was cooled. Soda and water mixtures to prevent rust, lard oil mixtures, and petroleum-base cutting oils followed rapidly. A better trained man integrated to using more power while working on a higher speed machine could produce more work with less floor space. And when Taylor showed what could be done with high-speed tool steel (1898), the highly flexible yet highly integrated unit system of production was here.

Other engineers worked along similar lines. Among them were Barth with his group drives, Gantt with his production mathematics, Galbraeth with his human engineering, and Emerson the idealist. They integrated men and machines.

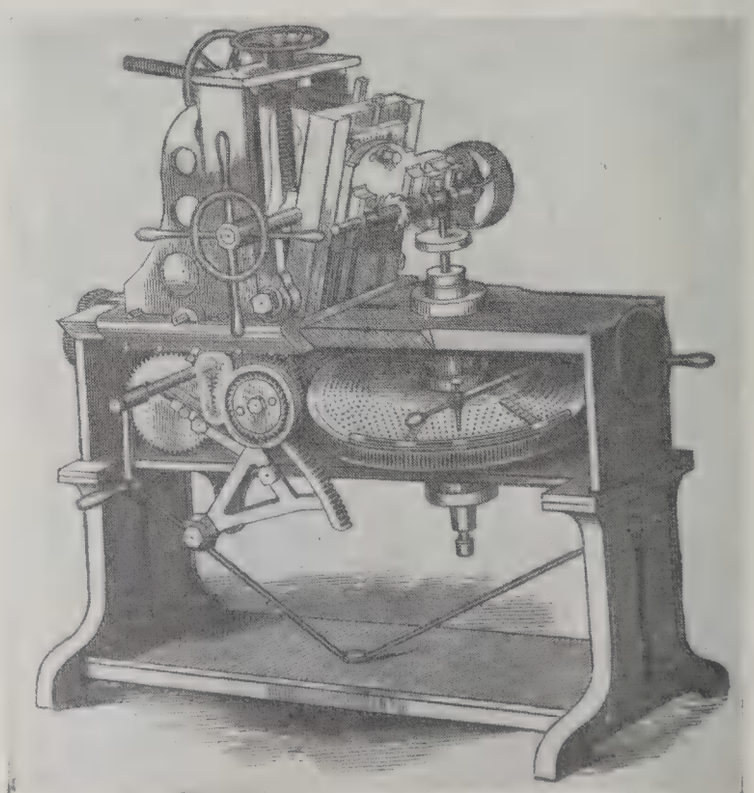
Power was lending itself to the new scene. Sprague (1884) had a constant-speed non-sparking electric motor good enough to be endorsed by Thomas A. Edison. The U. S. Metallic Packing Company (1882) was founded to make a segmented block packing which would solve problems for high-pressure, high-speed steam engines. Steam turbines finally became practical with the Parsons (1881), the De Laval (1885), and the Curtis (1898). With motors and turbines the age of high RPM received an impetus which never has stopped.

Pulverized coal (1890) increased the flexibilities of steam plants. The hot-bulb ignition engine (1883) showed the way to small unit power plants and still greater flexibility in manufacturing. Westinghouse pioneered the multiple-cylinder gas engine to save weight and space. The Daimler

Right: Universal milling machine made by Joseph R. Brown



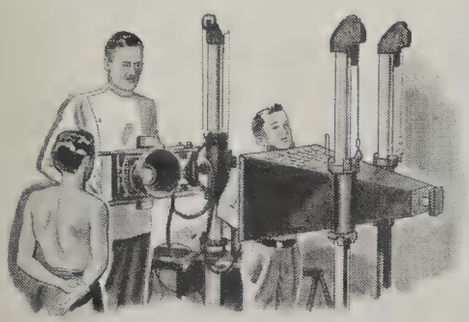
Below: Type of precision gear cutting machine built by J. R. Brown and Sharpe in 1855



WONDER-WORKING WITH ELECTRONS



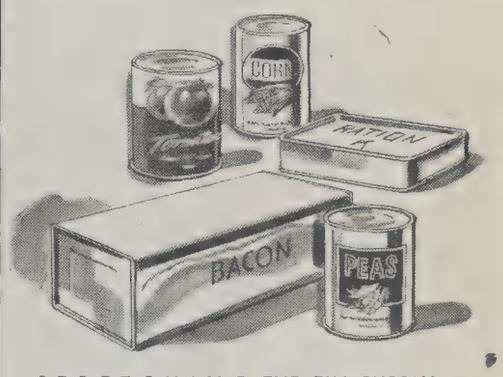
BOMBERS FROM THE BOTTOM OF THE SEA . . . There's a fabulous amount of magnesium . . . enough for 4,000,000 Flying Fortresses . . . in every cubic mile of sea water. To extract this vital metal from the ocean, vast quantities of d-c electricity are needed. An electronic device, the Westinghouse Ignitron, supplies this current by changing a-c to d-c — *right at the water's edge.* Ignitrons, with a combined capacity of more than 3,000,000 kilowatts, are now at work in magnesium, aluminum and chlorine plants, in electric railway systems, in mines, in many war industries.



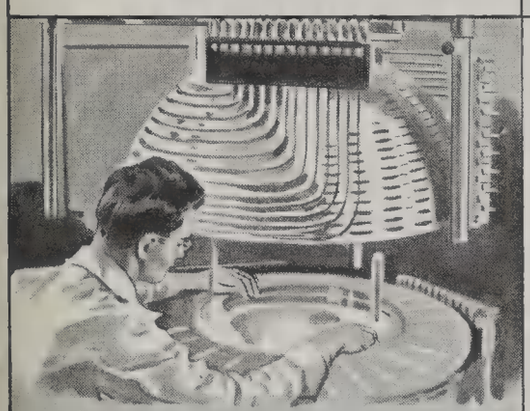
A NEW X-RAY machine, built by Westinghouse, makes possible the examination of 1000 school children daily — for symptoms of tuberculosis. X-ray pictures are taken by a 35 mm candid camera — at a cost of less than 1¢ per exposure.



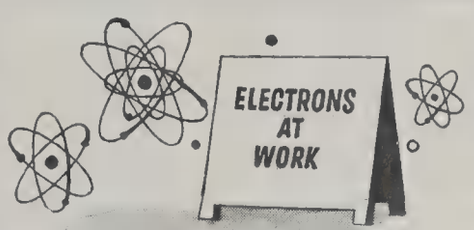
DUST TAKES A HOLIDAY . . . Dust-free air is absolutely essential in the assembly of optical equipment for our fighting forces. The Westinghouse Precipitron* electronic air cleaner automatically removes dust particles down to the size of 1/250,000*th* of an inch.



S-T-R-E-T-C-H-I-N-G THE TIN SUPPLY . . . Electronic high-frequency induction heating — developed by Westinghouse — helps save *two-thirds* of our war-scarce tin supply by flowing a protective tin coating, only 30-millionths of an inch thick, on steel strip.

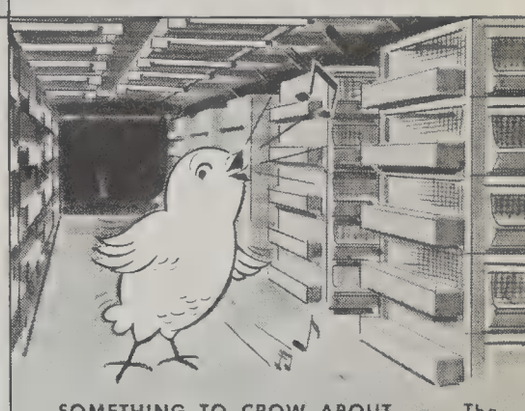


ELECTRONIC CHEMIST . . . The Westinghouse Mass Spectrometer analyzes intricate gas mixtures at amazing speed. In making synthetic rubber, for example, this electronic device cuts the time of chemical analysis from *days* to a matter of *minutes.*



Although one of the tiniest things in the universe, the electron is a gigantic force for the good of mankind. It is helping us to win the greatest war in history. It speeds production of goods for war and peace . . . brings entertainment into our homes . . . contributes to our health and happiness in countless ways. *And wherever you find electrons at work you will find Westinghouse electronic research at the forefront!*

*TRADE MARK REG. U.S. PAT. OFF.



SOMETHING TO CROW ABOUT . . . The Westinghouse Sterilamp*, an electronic device, deals sudden death to air-borne bacteria in brooder batteries — *has reduced chick mortality by 50%.* Sterilamps are widely used in restaurants, canneries, breweries, and many other industries.

Tune in:
JOHN CHARLES THOMAS
Sunday 2:30 pm, EWT, NBC

Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Tune in: TED MALONE
Mon. Tues. Weds. Evening,
Blue Network



Courtesy Automatic Transportation Company

One of the first contributions to systematic materials handling was the self-loading lift truck

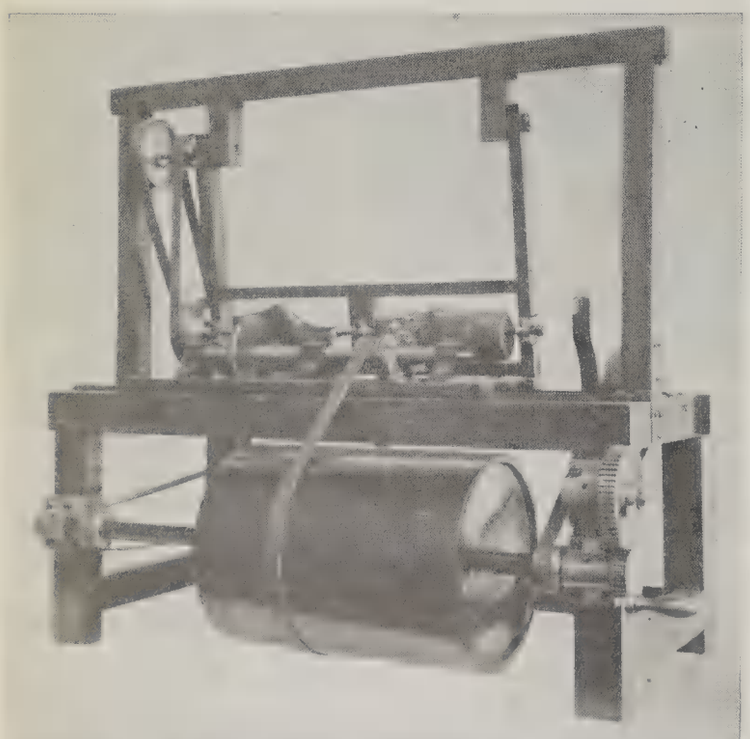
gas engine (1880) ran at 800 PM and weighed only 88 pounds per horsepower; its 200 RPM predecessors had weighed 1000 pounds per horsepower. The Maybach carburetor (1893), with ball float and needle valve, made modern gas engines practical.

BELTS, GEARS, CHAINS—Power transmission had gone definitely to belts, with gears and chains for small, intimate mechanisms. Hans Reynold (1880) made a roller-bushed chain. Forced feed lubrication arrived. Timken (1898) worked out a conical roller bearing to make his sulky run more easily—Timken roller bearings were on their way. Triple valves for Westinghouse air brakes (1887) opened the way to thousands of industrial uses of compressed air.

Ewart and others began applying his link-belt chains to scraper systems, bucket elevators, all sorts of materials handling devices. The Gandy belt was showing what could be done with belt conveyors.

Acetylene gas (1895), Elihu Thomson's first electric welder (1886), and Linde's liquid-air apparatus (1895), presaged the age of welding.

High RPM machinery needed better gears. Gleason's first automatic bevel gear planer (1894) and the Fellows gear shaper (1896), made such gears possible on a mass-production scale. The first Bullard Vertical (1883) and the Hartness Turret Lathe (1889) were integrations of machine building ideas which had been developing for nearly a century. Acheson's Carborundum process (1893), added hundreds of new possibilities to the fine grinding and accurate production



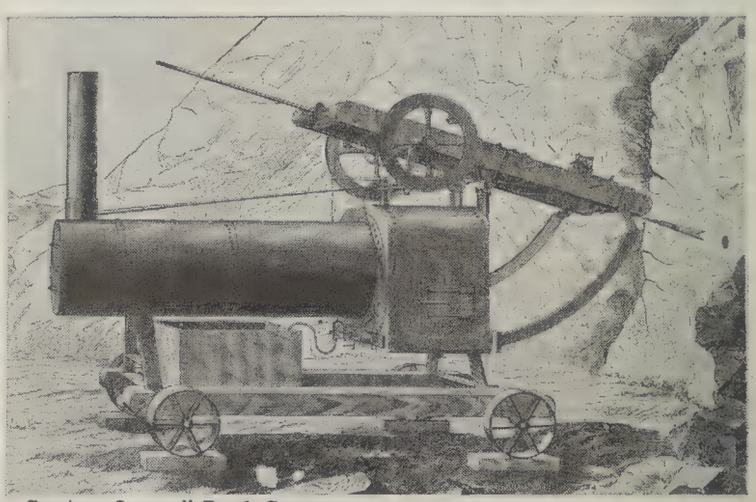
One of the early duplicating lathes, patented by Thomas Blanchard, 1843. U.S. National Museum

fields by providing a man-made abrasive superior to nature's.

Reece's button hole machine (1881) solved the most delaying hand-work problem of clothing factories and complemented the sewing machine in making possible the mass production of textile products. The Mergenthaler Linotype (1884), Edison's Kinetoscope (1893), Eastman's Kodak snapshot camera (1888), and the development of nickel steel (1889), each brought in a brand-new age.

MASS PRODUCTION—In the years 1900-1920, the mass production or "American System" proved itself to be the only one capable of bringing mechanical civilization to its full flower.

The Norton grinder (1900) was heavy enough to make accurate grinding a heavy production rather than a light supplementary operation. Diesel engines added another to the prime-mover types already available. Broaching was born. New Departure (1906) and Gurney (1905) showed that a single ball bearing could take both radial and thrust loads at high speeds—previous practices had called for one radial and one thrust bearing. Accuracies of .001 inch, previously regarded as fine, became coarse ones. Machines working to .00001 inch became common, with .000001 inch tolerances in plain sight. The Federal Products Corporation turned to dial indicators and other high accuracy instru-



Courtesy Ingersoll-Rand Company

Couch's rock-drilling machine, patented in 1849, was the first percussion drill made for this work

ments as an emergency measure to hold their skilled help (1919), and found the market almost unlimited. Spiral gears, bevels, hypoids, and herringbones became common; they could not have been used in an age when high precision was unknown.

The pooling of the automobile patents and others proved to be a much greater benefit resulting from World War I than could have been received from any grabbing of territory. The automobile assembly line became the merciless proving ground for every mechanical device or idea. Progress went into high gear and has never slowed down.

CHEMISTRY AND METALLURGY—With the 1920s, mechanical engineering was definitely becoming the servant of metallurgy and chemistry. True, the multiple V-belt drive (Dayton Rubber, 1921, and Allis Chalmers, 1923) was joining the silent chain, the greatly improved gears, the new types of electric motors and of variable speed mechanisms to replace long center drives and still further unitize machinery. And materials handling equipment—the lift truck dates from World War I—was turning whole factories into integrated machines.

But higher cutting machine speeds had to wait upon sintered carbides and other metallurgy. Stainless steels and other new alloys were making new machines possible.

Plastics, rubber products, insulations, protective coatings, welding rod coatings for shielded-arc welding, explosives to fasten rivets, concretes for firmer bases, metals cleaning compounds—all these and dozens more were in the chemical fields, and machinery advanced as and when they did.

These years served to demonstrate how completely mechanical engineering—in the United States at least—had become the servant of man. Let anyone mention a type of product he wanted to make or a production operation he



This Monster Amazed the World

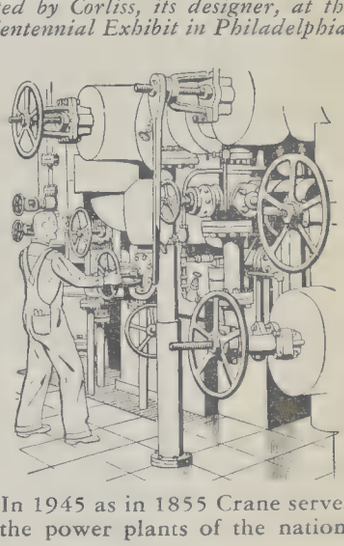
When Crane Co. was founded, inventors were seeking ways to harness the power of steam. One of the earliest successful engines was later exhibited by Corliss, its designer, at the Centennial Exhibit in Philadelphia.

When R. T. Crane first opened his little foundry 90 years ago, America was at the threshold of an era of economic development. A new age of power was at hand—power that would transform the simple economy of hand craftsmanship to an amazing age of mass production.

American inventive genius was already at work on new engines to harness the power of steam. Thus the founding of Crane Co. coincided with the revolution in power production and transmission that has built America to its dominant position as an industrial nation.

Through the years Crane Co. has kept step with the demands of power, furnishing pipe, valves and fittings to meet the needs of ever increasing pressure and temperature. Today, as when the monster Corliss steam engine amazed the world, the name Crane is familiar wherever power is produced. For any piping system, whether it handles steam, water or air, gas, oil or processing liquids, Crane can equip it 100%.

CRANE CO., 836 South Michigan Ave.
Chicago 5, Illinois



In 1945 as in 1855 Crane serves the power plants of the nation.

CRANE

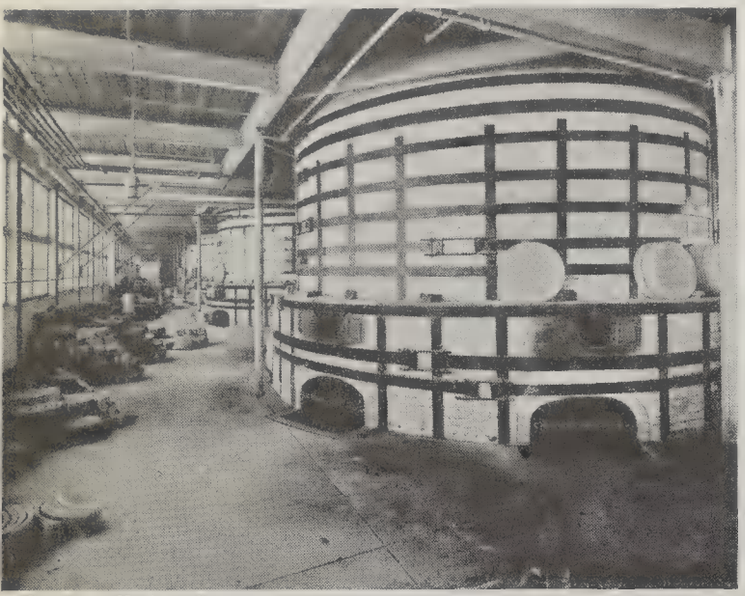
90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS

desired to perform, and if chemistry and metallurgy were ready with the necessary materials, then mechanical engineering would produce the goods.

Automobiles, for example, did not perform as well as was desired. Designers accordingly worked out the needed improvements without many worries about how the new, highly accurate, and intricate parts could be made. Machine-tool builders turned out special machines to do everything needed, and materials handling men followed through with the assembly lines to keep down the costs. Strip steel cost too much; the answer was the continuous strip mill which was made possible by modern, accurate anti-friction bearings. Airplanes could not be made fast enough; mechanical



Courtesy Norton Company

A row of old-style periodic kilns of the pottery type in which vitrified grinding wheels were fired

engineering devised the mock-up and the modern welding and riveting techniques.

In 1845 the machine age was taking hold. In 1865 the machine was master of the man. In 1945 the man is complete master of the machine. There is the story.

WHAT OF THE FUTURE?—From these facts, a few developments can be foreseen.

Accuracies will stabilize at the order of .000001 inch for a few years to come. Lubrication, warpage, metal creep, and other troubles must be overcome before they become finer.

RPM will go higher. Mechanisms operating at 100,000 RPM are in plain sight. They will make machines smaller, faster, more accurate.

Steam pressures have not stopped advancing. Experiments are being performed at 5000 pounds pressure. High-pressure steam will be stored as in a battery, used as needed.

Electronic instruments will perform the most exquisite inspection operations upon metal-working operations while the machines are in motion. The instruments will correct machine settings, eject partly finished parts if too badly mismachined to be corrected, detect flaws in raw materials, and eject the bad pieces before any work has been done upon them. As a result, high-accuracy operations upon intricate forms will be more practical.

Materials handling systems right now are in relatively the same stage of development as steam engines in 1845. There will be far more accurate and efficient methods with much higher integration of factories.

Machines and mechanical motions will become so controlled and trustworthy that far more of them will be totally enclosed. Accidents, therefore, will be greatly reduced.

Heat will be turned into refrigeration directly at the heat-exuding process, and the refrigeration in turn used to control waste heat or for other purposes. No longer will steel mills raise the temperatures of the rivers near which they are located.

Smokestacks will disappear from factories. The gases, heat units, and solid materials which they throw off are too valuable to waste.

Noise, vibration, and odors will be absent from factories. They are dangerous wastes that never should be tolerated.

The gas turbine will become one of the most important prime movers at all horsepowers but especially at 10,000 horsepower and up.

Power transmission sequences will contain far more governors; they will constantly compensate for changes in the power and speed requirements of processes.

Automatic controls will increase in numbers, efficiencies, record-keeping abilities, and integration.

Mock-ups, born in the aeronautical industry, will be used in every phase of machine design. They will have actual working parts including gears, motors, bearings, and mechanical motions. Often they will be made of glass or clear plastics.

Prestressing to achieve higher strength with lower weight and smaller cross-sections will be the most dramatic development of the next 15 years. It will solve millions of design problems.

Welding now is about where machining was in 1865. We have a fairly clear idea of how it will develop. But it has not even begun to give us its best.

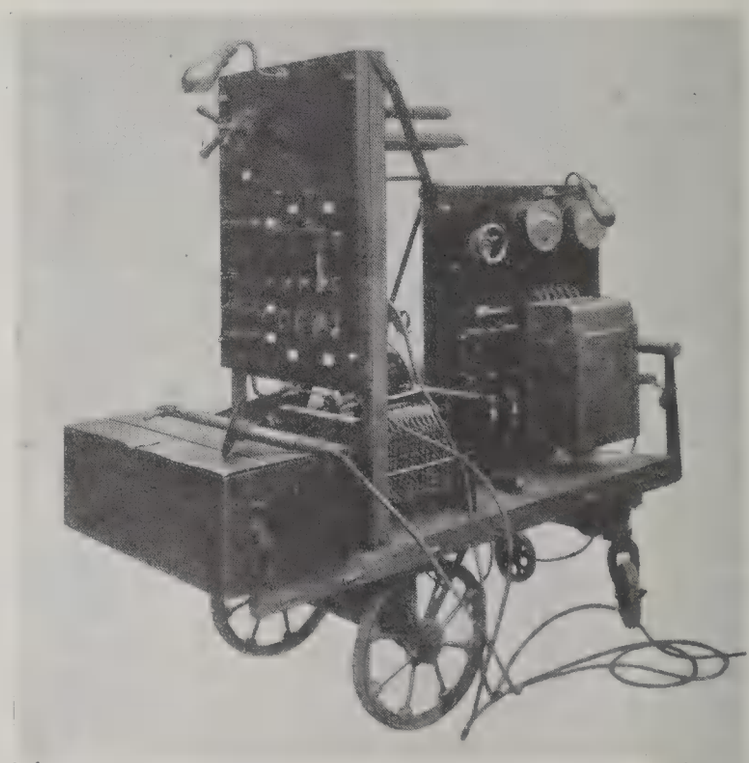
Upsetting and forging, both hot and cold, will be done with accuracies predictable to the order of .00001 inch. Extruding and stamping will be similarly accurate.

Standards and standardization will be developed to a point which will make our present efforts toward them seem like the drawings of kindergarten children. For standards are the back-bone of mass production. And mass production, the "American System," is the world's only hope that economies of plenty may displace the war-producing economies of scarcity and bring real civilization to all men.

Right: When Federal Products Corporation developed dial indicators to aid unskilled help, they found a hungry market in industry, ready and waiting for precision equipment of this type



Below: In 1915, The Lincoln Electric Company built this 200-ampere welding machine to sell for $1550. By 1941 they were producing equipment of similar capacity, but greatly improved, for a selling price of $200



Your best man is a better man with JO-BLOCKS back of him



CERTAINLY, a good mechanic will "feel his way" through a job with all the accuracy it calls for. But he'll do it faster, with more sureness, more pride in the result and less worry over possible errors if he's got JO-BLOCKS to work with. The super-accuracy of Johansson Gage Blocks (to .000004 or .000008) is positive insurance that your coarser tolerances of thousandths or "tenths" *can be maintained.* And JO-BLOCKS are working tools, too, for laying-out, locating, scribing, checking work, as well as checking gages and mikes. Popular No. 1 Set of 81 pieces makes 120,000 different size gages in steps of .0001, from .200 of an inch to more than 12 inches. Deliveries now within 30 days. Write for catalog. Address: FORD MOTOR COMPANY, Johansson Division, Dept. SA, Dearborn, Michigan.

Ford

Johansson

GAGE BLOCKS

Plastics' Future

Can the Industry Handle the Huge Volume of Business that Will Certainly be Available When Peace Comes? Some Figures on Machinery, Production Processes, and Materials Indicate that Engineering Design Is Providing Equipment and Methods of Outstanding Future Importance

"WHAT is the present capacity of the plastics industry? What new production methods are being employed in it? What are the figures on new equipment ordered but not yet installed, on the monthly consumption of plastics materials, and on plans for plant expansion?"

These questions are being asked both by the plastics industry and by the end-users of its products. Despite their present absorption in the production of armaments, American manufacturers are now laying plans for peace-time manufacture of their own lines.

Since these plans depend, necessarily, upon the ability of the companies to get delivery of component parts, interest is high in the ability of the plastics industry to handle the volume of orders that will accompany resumption of civilian production. This interest extends not only to those who have used plastics in the past but to a large number who expect to use them for the first time in their post-war products. Members of the plastics industry also want to know all about its post-war destiny.

In an effort to answer these various questions, a survey was conducted recently by means of personal interviews plus a questionnaire mailed to 500 molders, extruders, and laminators who constitute the bulk of the industry. On the basis of these reports the plastics industry looked like this when the Japs sneaked in on Pearl Harbor: Some 500 molders were operating approximately 9000 presses of which 8000 were compression and 1000 were injection types. There are no authentic figures on the machines used for plastics extrusion at that date because the process then was just coming into its own. The average monthly consumption of plastics molding compounds of all kinds was approximately 13,000,000 pounds in 1941—of which 82 percent was consumed in compression molding.

OVERALL INCREASE — Despite drastic restrictions on machine production, the three years between 1941 and 1944 saw an overall increase of 44 percent in compression and 50 percent in injection presses. The extrusion machines in operation in 1944 are separated into those used for coating wire alone and those doing other types of plastics extrusion; no rubber machines are included. It is possible that the time will come when some of the 330 machines that are now working exclusively on wire insulation will be diverted to other types of plastics extrusion.

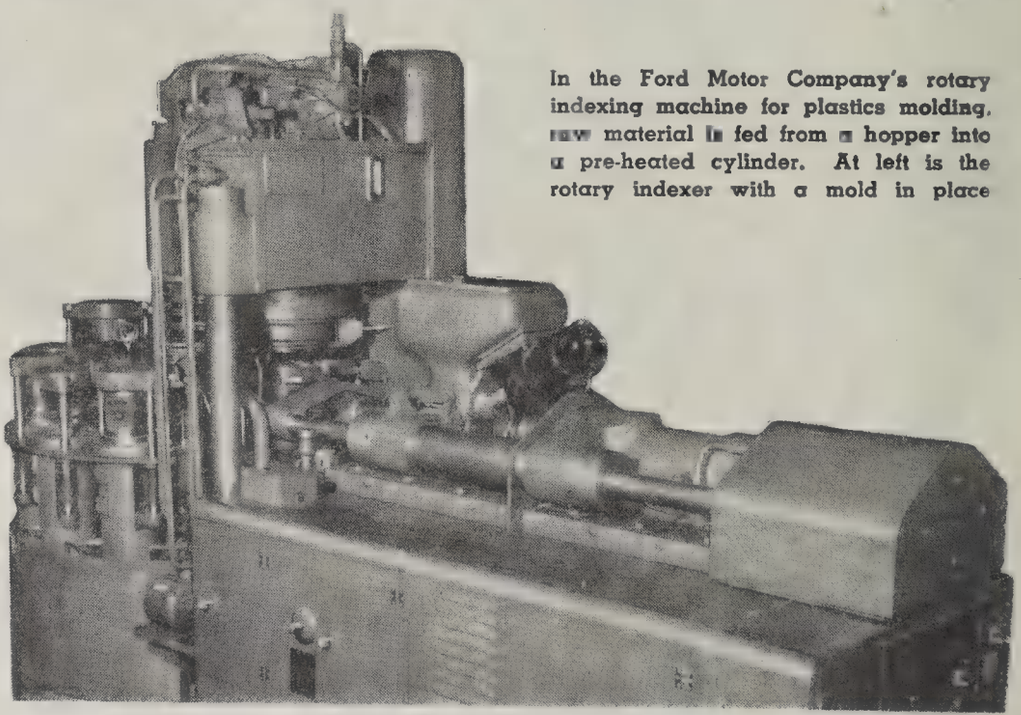
The increase of 44 percent in the number of compression presses since 1941 has outstripped the 23-percent increase in thermosetting molding compounds that has resulted in a present monthly production of 12,500,000 pounds. This increase would be even more impressive if it were weighted to allow for the larger presses and the automatic presses installed since the beginning of the war.

The same situation exists with respect to injection machines and current production of thermoplastic molding powders, although the uninterpreted figures would seem to indicate that the reverse was true. Statistics gleaned in the survey show that, since 1941, thermoplastic molding powder production has increased 165 percent (to a current monthly consumption of 6,350,000 pounds) while the number of injection machines has climbed but 50 percent.

However, to this latter figure should be added some of the extrusion machines because compounds used for extrusion, with the exception of the vinyls, have been included in the total thermoplastic production. With the existing 350 extrusion machines of the non-wire-coating type added to the injection machines, the total increase is about 85 percent instead of 50 percent.

And still the figures are misleading. Back in 1941 and 1942 almost all the machines were two-, four-, and six-ounce units while at least 400 of the 1500 injection machines which were expected to be in operation by the end of 1944 were listed as eight-ounce or more. Estimates indicate that 400 eight-ounce machines or larger can use up as much or more molding material than the 1000 older and smaller machines listed for 1941. Hence it is obvious that the capacity of processors to handle molding compounds has increased out of all proportion to the actual number of presses.

The number of hours in the present workday must also be taken into consideration. If the plastics industry could handle 2,400,000 pounds of thermoplastic compounds a month in 1941 in a 12-hour day, with 1000 smaller presses, it can handle at least 4,000,000 pounds a month today in a 24-hour day. The new and often larger machines, plus 100 or more extrusion machines, will therefore take care of the



In the Ford Motor Company's rotary indexing machine for plastics molding, raw material is fed from a hopper into a pre-heated cylinder. At left is the rotary indexer with a mold in place

2,350,000 pounds remaining from the current consumption figure of 6,350,000 pounds.

FURTHER EXPANSION—This overall increase in compression and injection presses during the last three years has not satisfied the molding industry. It is planning a 21-percent expansion, according to its answers to the survey question, "Have you definite plans for additions to your plant and, if so, by what percentage will the additions increase your plant size?"

Obsolescence of facilities is, of course, a factor after the last four years of all-out effort to keep our military forces supplied. There have been few replacements of machinery during this period. Operators are eagerly awaiting the day when obsolete or worn-out machines can be melted down for scrap. There is the possibility that if the emergency lasts over an extensive period, the machinery situation would seriously interfere with production. Fortunately, most of the obsolescent equipment falls in the small sizes where its loss would have a lesser effect on output.

For some time the plastics molding and extruding industry has been guessing what the equipment manufacturers have in store for them. Most of the items supplied to the Armed Forces have been made on equipment of a type in existence before Pearl Harbor. Nevertheless, despite the lack of manpower and the diversion of engineering facilities, many important changes in design have taken place since that time. In addition, equipment suppliers to the plastics industry have been storing ideas, some of which have been tried and proved.

According to information gathered during work on this recent survey, the machinery trend is toward larger and larger capacity, hence toward faster production and lowered cost to the consumer. One of the leading press manufacturers planned to produce only 10 four-ounce injection presses during 1944. His six- and eight-ounce schedule was for 60 while his 16- and 22-ounce machine production was set at three each. Even 36-ounce presses and larger are in the talk and blueprint stage.

The attitude in some sections seems to be that the plastics industry has thus far been slow to follow the American practice of standardizing and then producing on a mass basis so as to achieve a better product at a lower price. This is attributed partly to the fact that the development of new materials and new processes has been rapid, and partly to the relatively small size of most of the processors of plastics materials. Standardization, however, presupposes extreme flexibility wherein one machine, for example, can handle a variety of materials.

INJECTION AND EXTRUSION — In line with this trend, the Chrysler Corporation has recently developed an unusual injection and extrusion machine. It offers great possibilities in both the thermosetting and thermoplastic fields. In its design, particular emphasis has been given, thus far, to the injection and extrusion of thermosetting compounds. In contrast to standard injection machines which employ a ram or plunger that feeds prescribed amounts of compound into the die cavities, this machine employs a worm screw which makes possible continuous feeding of the plastics materials. (See also page 40, January 1945, Scientific American.)

The original Chrysler machine just mentioned was built by Walter P. Cousino, project engineer in the Engineering Division of the Chrysler Corporation. Utilizing the reciprocating plunger principle, it became known as the single plunger type. In this first model, which processed only thermoplastic materials, the powders were loaded into a circular hopper from which the reciprocating plunger fed the plastics granules into a heating unit where the material became plasticized under electrical heat. The mold was then closed, and the plunger started again to feed the plastic into the cavity of the die. As soon as the mold became filled, the excess material backed up as overflow around the nozzle contacting the sprue of the die. At this point a valve was closed.

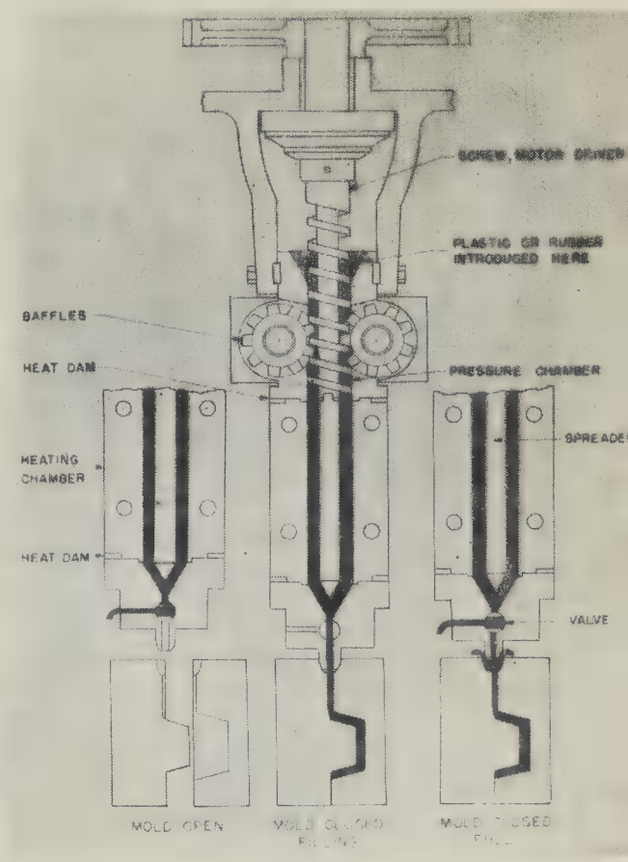
The success of this original unit led to the development of a second machine—the design of Mr. Cousino and other Chrysler engineers—which was equipped with two reciprocating plungers instead of one. After preliminary work with thermoplastic materials, the machine was tried out with thermosetting plastics such as phenolics. As experiments progressed, it was noticed that better results were obtained with thermosetting materials than with thermoplastics.

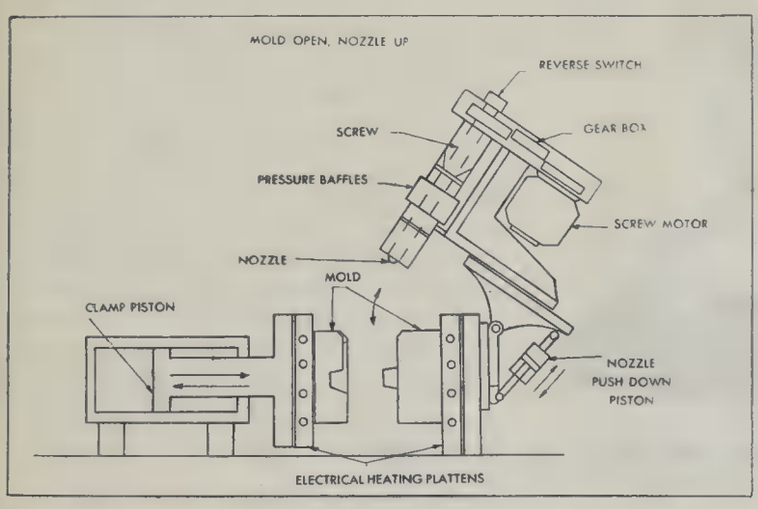
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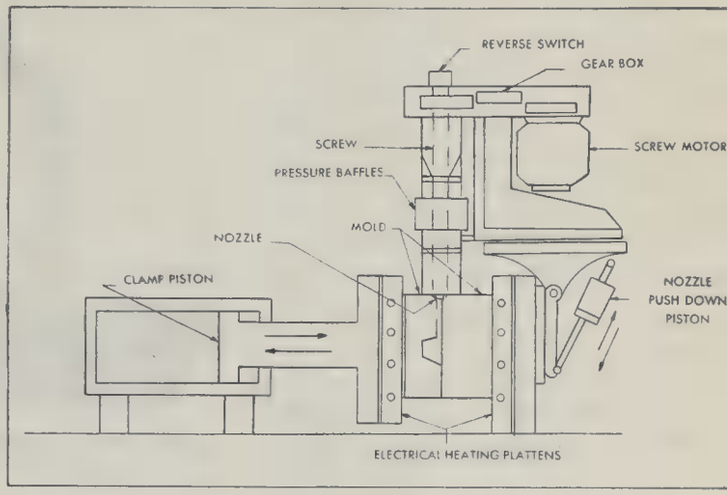
High pressures in the Chrysler screw-injection molding machine are obtained by the aid of baffle gears which prevent the molding powders from backing up on the screw exerting the pressure

Lower left: The Chrysler machine in open position

Lower right: The same unit as at left, but in the molding position. The push-down piston has lowered the extrusion head and the nozzle is in position to extrude the material into the closed mold







pany engineers was directed to a part about 18 inches long and two inches in diameter with a ⅛-inch concentric wall. Injection molding of this part was difficult in view of the fact that a removable mandrel had to be used to make possible the removal of one molded part from the press while another was curing in the die. A suggestion that the tube be extruded led to the latest development of this machine whereby the extrusion of thermosetting plastics on a continuous basis was achieved. To make this possible an extrusion die was mounted against the front end of the injection head.

SCREW INJECTION — Although the double plunger machine had given good results, it was decided to substitute a screw injector driven by an electric motor. This change has the advantage of giving continuous injection of the material, regardless of its bulk, until the mold cavities are completely filled. Thus, instead of having a machine limited to parts weighing up to 12 ounces, company engineers were confident of being able to mold much heavier pieces.

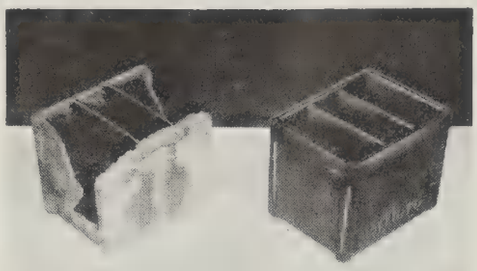
To verify this, a battery box requiring eight pounds of paper-base phenolic was first molded on the screw injector machine and then on the same machine after the screw had been replaced by the double plunger type of injector. One of the photographs shows the results. The battery box molded with the double plunger injector did not fill out completely while the other test piece was perfectly satisfactory.

When thermosetting plastics are molded with this Chrysler machine, a screw first feeds the molding powder from a convenient hopper into the heating chamber. As soon as this chamber is filled, the screw is stopped and the plastic material subjected to heat for 15 to 20 minutes. After this interval the injection head, already heated to the proper molding temperature, is lowered against the clamped die so that the nozzle seats tightly against the concave entrance of the sprue adaptor. The screw is again started, injecting the heated material by pushing it with cold material from the hopper. As soon as the die is filled the screw is stopped.

Finally, after the material is cured, the die is opened and the molded part ejected by a suitable mechanism. Then the die is again closed and the next cycle started by lowering the head against the die. The baffle gears, a unique feature in this design, are responsible for the high injection pressures obtained in this machine (up to 22,000 pounds per square inch) since they prevent the molding powders from backing up into the top of the screw and into the hopper.

Most of the results obtained thus far have been on a pilot plant scale. They would seem to indicate, however, that it is only a matter of time before the Chrysler screw injector machine will be ready for mass production of plastics—a result that has already been achieved with rubber. The machine has been developed primarily to inject large parts because the company feels that there is a definite need for such equipment if plastics are to find increased uses, not only in the automotive but in other fields as well.

Another recent successful development, by Hydraulic Press Manufacturing Company, is a rotary indexing machine—built to Ford Motor Company specifications. This machine has



The battery box at the right, perfectly formed, was molded from plastics with screw injection. The one at the left, molded by double plunger injection method, did not fill out

made possible the continuous, large-scale injection molding of truck oil cases from a variety of thermosetting materials. In operation the continuous injector is similar to an aircraft machine gun synchronized to fire through its revolving propeller blades.

Raw material from the elevated hopper feeds into a small cylinder where a slowly revolving screw pushes the proper quantity of material necessary for a single casting into a large cylinder. In the large cylinder, the temperature of the plastics is gradually raised as it progresses toward the nozzle or point of injection. At this point a hydraulic injection clamp holds the nozzle in place while the plastics material is forced into an electrically heated mold. Once the casting has been made, the mold is released from the injection position, to be replaced by the next mold on the turntable—and so through all the stations on the indexing machine. Meanwhile, the temperature of each mold after it is charged with material is carefully controlled until the die is ready to be opened and the casting removed.

The advances that these and other machines promise for the post-war period are given increased emphasis when it is remembered that less than 15 years ago an injection-molding machine consisted of a letter-press affair into which a teaspoonful of material was placed and electric or gas heat applied to melt the plastics. Then the material was injected by hand into a mold to make a miniature piece having a volume of only a fraction of a cubic inch.

REDDY KILOWATT

Is Molded of Cellulose Acetate

OVER 200 power companies in the United States, Alaska, Canada, Cuba, Argentina, Brazil, Hawaii, San Salvador, and Portugal are using in their advertising and public-relations programs a small cellulose-acetate model of the trade character, Reddy Kilowatt,



This lively symbol of electricity is injection molded of cellulose-acetate

supplied by Ashton B. Collins. The figure is injection molded of Fibestos by the Mack Molding Company in seven separate pieces. The head is painted by hand in a finishing operation in order to attain the exact facial expression indicated in the original model. Ready Kilowatt has proved popular with power companies for display purposes—so popular, in fact, that the figures are being sold as novelty items. Because of the bevelled edge, distinct lightning-like flashes can be observed when a light is moved behind the figure.

GUN COVERS

Provide Protection as Well as Flotation

ASSAULT troops must come in fighting. To keep their firearms ready for immediate action regardless of the soaking they receive during the landing operations, the Army has adopted flexible water-proof gun bags which offer complete protection to the equipment enclosed in them.

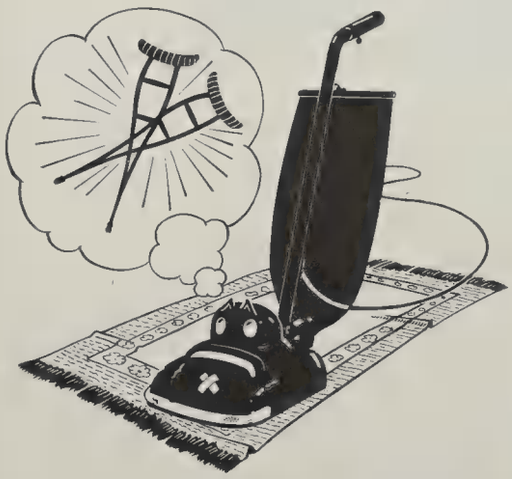
After a gun is placed in one of these bags, it can be closed tightly by a simple knot. Enough air is trapped inside so that the bag and gun will float for an indefinite period if dropped in the sea. The Lumarith V.N. (vinyl chloride vinyl acetate copolymer) from which these bags are made by Shellmar Products Company is so flexible that men armed with pistols, rifles, or machine guns can manipulate the trigger and begin firing immediately without pausing to remove the protective wrapper.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- IMPREGNATING RESINS
- RESINS FOR PROTECTIVE COATINGS

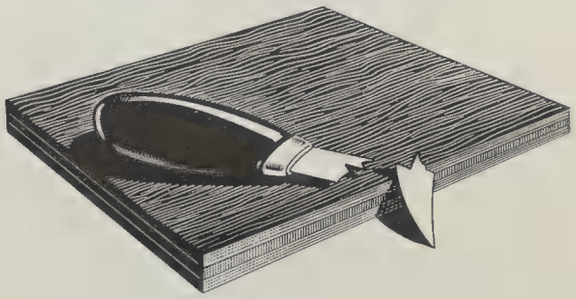
MOLDING COMPOUNDS



IT'S NOT THE RUG THAT TAKES THE BEATING

It's the good old prewar vacuum cleaner itself that's taking the beating these days. However, if yours is one of those which are housed in durable Durez phenolic plastic cases, these cases will take plenty of punishment and still do their job. For the Durez phenolic molding compound used for this purpose possesses excellent impact resistance properties which insure the vacuum cleaner of a long useful life. Add to this, the snappy looking appearance and perfect insulation which this Durez housing affords and you can appreciate the benefits of selecting a plastic that fits the job. There are more than 300 versatile Durez molding compounds which are daily proving their worth under all types of conditions in thousands of different products . . . compounds which are valuable to men with imaginative ideas for post-victory markets.

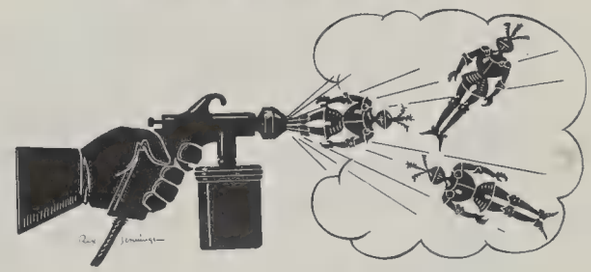
IMPREGNATING RESINS



HOW TO BREAK A WHITTLER'S KNIFE

Just let him go to work on some Durez resin impregnated plywood, he'll think he's whittling on a rock. For Durez impregnating resins not only produce a permanent bond, but impart tremendous hardness and strength to the wood. The unusual properties which these phenolic resins give to wood — in making plywood — have rendered them invaluable to wartime industry . . . and to progressive post-war planners.

RESINS FOR PROTECTIVE COATINGS

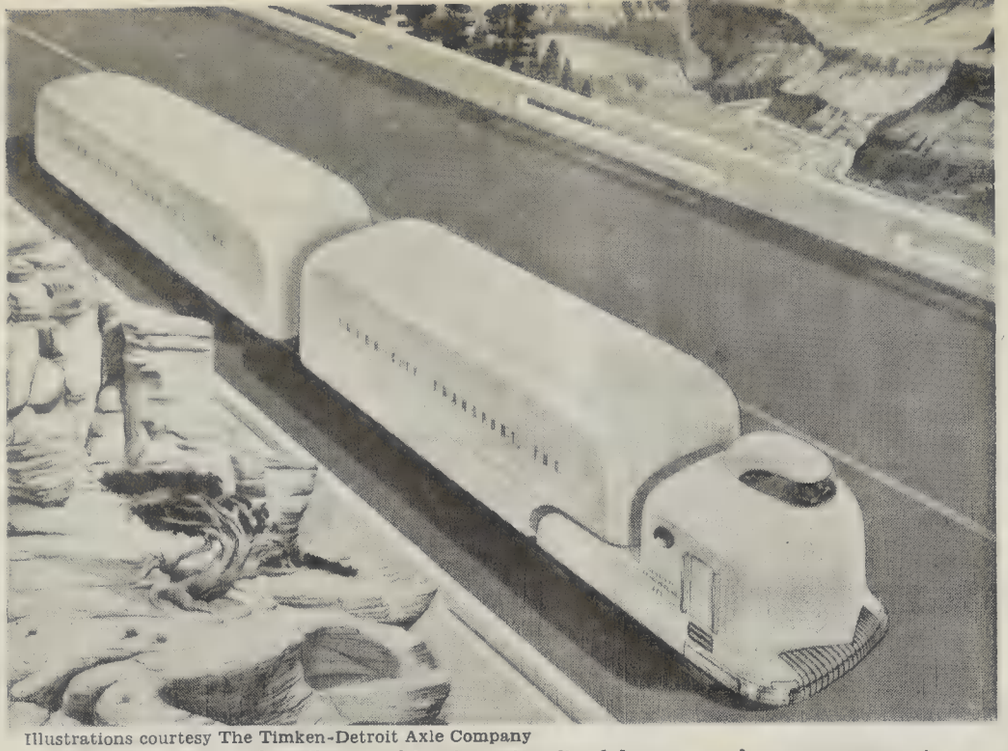


ARMOR FOR METALS

Even the toughest of metals need protection . . . from corrosion, moisture, acids, alkalies, etc. Durez phenolic resin varnishes provide this to the utmost degree, with ease of application as an added feature. As protective coatings for machinery, automobiles, metal equipment, the insides of metal containers, and similar type products, these phenolic resins are daily doing a tremendously effective job.

As a man of science you naturally are interested in plastics. The above is but a quick glance at the vast scope of Durez operations. The quarter century's experience in successful product development in practically all fields of industry that's behind Durez technicians would fill volumes. This background embraces the entire field of *phenolic* plastics from molding compounds through industrial resins to the oil soluble resins. The complete line of phenolics which Durez produces has been developed only after extensive research has proven each phenolic to be outstanding for the specific job for which it was designed. The resource which the Durez organization has to offer are available towards the successful development of practical industrial applications. Durez Plastics & Chemicals Inc., 522 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB



Illustrations courtesy The Timken-Detroit Axle Company

The inter-city truck-trailer combination visualized here may be one answer to the motor-transportation industry's constant striving toward carrying heavier loads faster and with greater safety. It is designed to utilize all load space to the fullest and would be constructed of light materials for economical operation

IGHWAY TRANSPORTATION

Conducted by LESLIE PEAT

Tomorrow's Vehicles

Immediate Post-War Output of Trucks and Busses Will be on a Basis of Current Models. But, as Soon as Possible, Manufacturers Will Put Into Commercial Vehicles All the Proved War-Born Advances in New Alloys, Plastics, Synthetic Rubbers, and Improved Engines

WHAT KIND of trucks and busses will roll along the highways of the United States in the years immediately following the war? The answer to this question is of great interest to intensely automotive-minded Americans. The answer is that, to begin with, they can expect no startling changes. Immediate post-war trucks and busses will be basically the same as pre-war vehicles. Because of the hungry market for new vehicles, any and all types will show an increase in the hands of users. Current production types are the basic models for most of the Army and Navy trucks, and have been service-tested through the years as commercial vehicles.

Manufacturers are confident that these current types are the best vehicles that can be produced quickly and in large volume as soon as materials and man power are released from war production. The jeep, of course, is being widely considered as a possible war-born vehicle for tomorrow, and the amphibious "duck" also may find a role in civilian life when peace comes again.

Basically, there have been improvements in alloy steels, considerable development in plastics, and tremendous strides in synthetic rubber during the past few years. Most of the future engines, however, will still be of the gasoline type. Diesel engine builders expect a spurt in sales based chiefly on an increased use of present models rather than on any striking improvement in the Diesel engine itself.

THE NEW CRITERION—A new philosophy in steel specifications has come into being as a result of the shortages of steel alloying materials. This is "hardenability." New steel specifications are based upon the relative ability of steels to harden under given heat-treating processes. The theory behind this is that hardness of steel is an indication of its strength. Thus the chemical specifications are taking a back seat, and data of practical use are being offered to the designers of machinery parts. All the designer wants to know about a material is its physical properties and its machining, welding, finishing, and other manufacturing characteristics. This is one of the legacies of coördinated research work stimulated by the war.

The Diesel engine will probably continue to be used more extensively over long hauls where the economy of fuel in relation to ton-miles hauled will make or break the operator. Diesel engines cannot be throttled down to as slow idling speeds as the gasoline powerplant, and are rougher in operation. Because of their greater operating pressures, they must be built of sturdier alloys and are heavier and more costly than gasoline engines of comparable output. They have been improved, however, during the past five years. The gasoline engine, on the other hand, stands only a little ahead of where it was a decade ago—insofar as overall economy of operation is concerned.

TIRES—Of all post-war automotive prospects, the synthetic rubber tire is the most intriguing subject for engineers and the public alike. Some of

the nation's leading chemists expect their test tubes to produce a rubber far superior to natural gums. Others are brave enough to believe that the price of synthetic tires will equal that of those produced from natural rubber before the war. Plantations have been hard hit by Japanese seizure, and the necessary period of re-establishing the natural rubber resources of the world will give the chemists a little more time to do their stuff. The new silicone synthetic rubber appears to have advantages possessed by neither crude nor the petroleum and alcohol-base synthetics. These superior qualities seem to make it better for a number of uses, notably inner tubes.

As manufacturing technicians advance in their pioneering work in handling synthetic rubber materials, the cost of the material itself may become less important. Fleet operators and motorists are interested primarily in the cost per mile of tires, and the laboratories know that this cost is on the way toward—and they hope beyond—competition with natural crude rubber as far as *price per mile* is concerned.

BETTER TRANSMISSIONS—During the past decade, transmissions have been the bane of vehicle designers. Fully automatic power transmission for motor vehicles has long been a dream of inventors and knowing motorists, and some steps in this direction already have been made. Several companies are spending a great deal of development energy on this component for the post-war vehicle.

Jet propulsion has opened a new door to thought about transportation powerplants of the future. The intense research and development now being done under the aegis of the Army Air Forces and Navy Bureau of Aeronautics may be the first step toward obsolescing the gasoline and Diesel engines. The answer will lie in economics. Even if the jet or gasoline turbine engines of tomorrow are foolproof, the factors of first cost, maintenance expenses, and miles per dollar eventually will decide the question of practicability.

Several manufacturers have already placed orders for machine tools designed to make parts for gasoline-injection systems. The number of tools ordered indicates that carburetors will face stiff post-war competition. Experience gained in the aircraft field proves that gasoline injection has a number of important advantages over carburetors—even for highway vehicle use.

Extensive economic and technical studies are being made today on the motor fuels of tomorrow. In general, pending a more complete report on the details in Scientific American at a later date, the bulk of post-war motor fuels will probably be gasolines of about 70 octane and less. This disturbs engine designers who yearn to bring out vehicle engines of higher specific output, but it nevertheless appears to be a fact.

AERODYNAMIC INFLUENCES—Considerable work has already been done to adapt aircraft design structure principles to automotive vehicles. Several experimental cars and buses have been built along airplane structural lines and it is only reasonable to expect others. The aircraft manufacturers have talked some about getting into the motor vehicle business, now that they have had experience in mass production.

Motor vehicle manufacturers, on the other hand, are so certain that strong dealer organizations are necessary to sell and service cars, and to distribute trucks and buses, that they have no fear of important inroads into their business. As far as the public is concerned, the merger of aeronautical design ideas with the design of motor vehicles will bring interesting innovations.

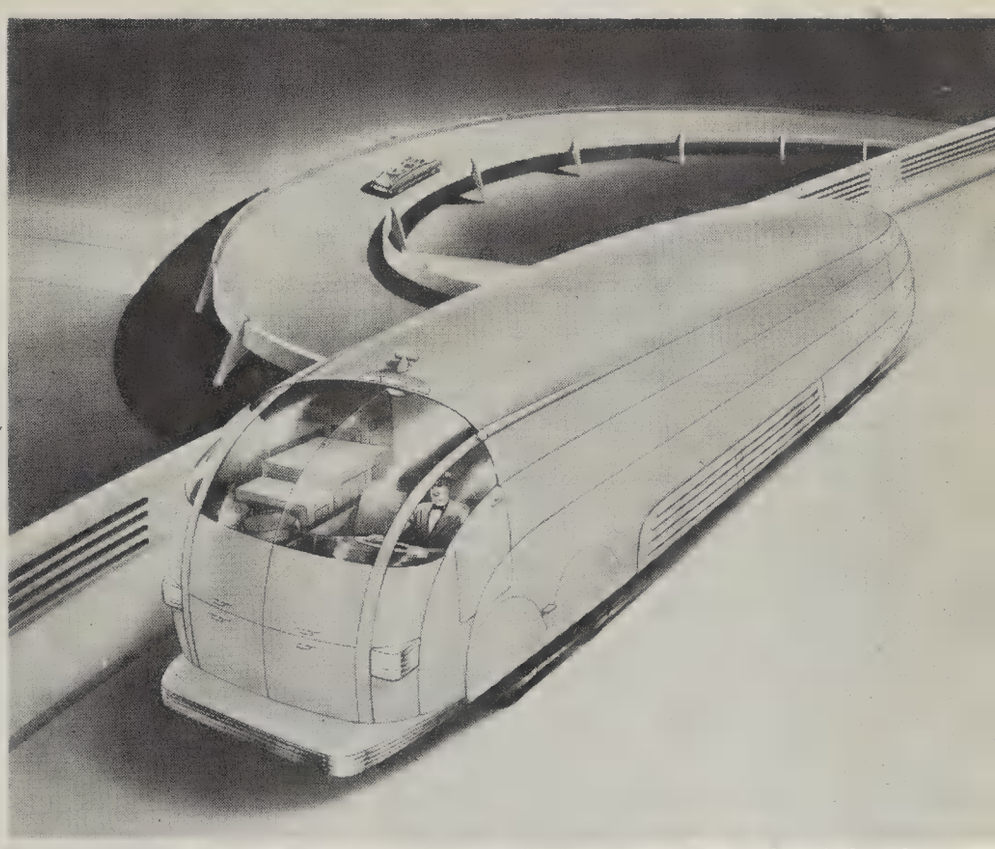
An example of the potential influence of aircraft design on the automotive industry is found in the fact that several decades of normal development work on air conditioning have been telescoped into three or four war years in the aircraft industry. The vehicles of the later post-war period will certainly reflect some of these advances, since the automotive industry was moving in this direction before the war. The final decision as to acceptance of such innovations will depend upon first cost plus maintenance expense in relation to the increased comfort of better ventilation, heating in winter, and cooling in summer. Commercial trucks, too, will benefit from this work, and the post-war refrigerated trucks for perishable foods will be far more economical and effective than their pre-war granddaddies.

Structural engineers in the automotive industry are working on applications of new synthetic materials such as paper and cloth impregnated with plastics, plywood molded sections, and some of the lighter metals which will be more abundant than ever before as a result of increased capacity built for the war effort. As far as production models of cars, trucks, and buses are concerned, the deciding question again will be price. As long as the post-war price of aluminum extrusions, sheets, and forgings are unknown, production engineers are still thinking in terms of pre-war metals for automobiles and trucks. Ingot aluminum prices mean nothing to design engineers.

BRIGHT FUTURE EXPECTED—Post-war highway transportation prospects appear bright enough without indulging in fanciful air-brush dreams of streamlined curves and pastel shades, although a number of companies have done some of this rosy day-dreaming in off moments. The basis for solid, feet-on-the-ground optimism in regard to the automotive business can readily be seen when we remember that the industry of keeping commercial and private trucks in operation amounted to a billion dollars yearly in pre-war years. As much or more was spent in the operation and upkeep of bus lines. The huge school-bus outlay reaches astronomical figures in total annual mileage, gasoline consumption, and maintenance costs. In 1943 the chartered bus lines alone took in more than $1,000,000,000, and the 9000 buses in use cost about $90,000,000 when new.

Important as were the economics of the truck, bus, and parts manufacturers in the immediate pre-war era, operators are looking forward to huge expansions of their operations. Here are some of the reasons:

Industry has been decentralized during the war emergency period in the United States. Factory expansion has largely been achieved out-of-town, in small communities where real estate was not prohibitive in cost and where the labor market had not been already tapped. One Michigan armament manufacturer, for example, extended his manufacturing line 125 miles by having parts trucked for various operations to five plants in three towns—all within a fifty-mile radius. Lack of



Advantages of front or rear loading would be offered by trucks of this design



One of the most important transportation lessons learned from the war is that specialized vehicles do a given job faster and more economically. Such lessons may someday lead to the construction of dump trucks of this type. The side-cab gives perfect visibility and, because of the steering-driving axle at each end, the vehicle can be driven in either direction without the necessity of turning around

local foundry, machining, and annealing facilities forced him into this roundabout proceeding which proved economical in the long run and permitted him to meet his shipping dates for finished artillery shells.

Second, home deliveries of retail merchandise and foods have extended further from centers of urban areas during the past two decades. This trend has been accelerated in the past three years. It will continue, but at an increasing rate when the post-war home-building business gets started after V-E Day.

Twenty major cities in the nation receive all their milk by truck, and a substantial majority of all milk received in all American cities and practically every town and hamlet in the country depend upon trucks. The same is true of other farm produce. Most of the retail deliveries of food from coast to coast have been depending upon commercial vehicles of one type or another for more than a decade. Nearly 5,000,000 motor trucks were registered in the United States in 1941. More than a quarter of these were used by farmers. Nearly another quarter were used by entrepreneurs and firms in the grocery, creamery, meat, bakery, and other food businesses.

In the third place, the war has brought far more coördination into the economical and technical details of highway transportation than has ever been known in the past. The Office of Defense Transportation and national engineering societies interested in highway transportation—such as the Society of Automotive Engineers and technical committees of the American Transit Association—have brought together a vast amount of engineering and operating data. They have analyzed this information to develop reports on improved use of vehicles during the war emergency.

As a result, many operators know more about the business than ever before. An important by-product of this work has been a better understanding by vehicle designers of the specific needs of the truck and bus user. Although lacking the showmanship of an automobile salon, this new philosophy may be counted upon to stimulate better design of trucks and make bus travel more comfortable in the years to come.

HIGHWAY EXPANSION FORESEEN — Highway authorities are agreed that huge sums will be spent on roads of all types in the immediate post-war era. State gasoline and vehicle taxes for this purpose are expected to continue ($15,000,000,000 in 1941 and $13,000,000,000 in 1942) and a number of Congressmen have Federal highway aid bills ready for the "hopper" on Capitol Hill. Pressure of local constituents for better roads may be expected to continue. A number of large road building programs halted by the war will fan out from our great centers of population to increase the 1,583,734 miles of hard surfaced roads and streets and the total of more than 3,000,000 miles of surfaced roads and streets in the United States.

World War II may be counted upon as a gigantic stimulus to the increased use of motor transportation of all types, just as World War I cradled the development of the motor truck and bus. Today's modern armies have been almost completely mechanized. The world battlefronts have provided a vast proving ground where innovations of a few years ago have been proved by hard usage over all types of terrain and in all extremes of climate. Reports on performance are made to the manufacturers, both through Army channels and directly by engineers assigned to duty with the Army as automotive, fuels, and lubricants technicians. As a result, design engineers have a wealth of information as a background to many improvements which they eventually will pass on to the public.

It appears probable that post-war truck and bus production will hit new highs as soon as material and manpower is available for civilian production. In 1941, more than one million motor trucks were manufactured in the United States at a total wholesale value of more than one billion dollars. If the market is not flooded by the vast fleet of used Army trucks, vehicle manufacturers will be busy for several years after peace comes, catching up on needed replacements.

This means that the numerous factories of General Motors, Chrysler, and Ford, as well as the major truck, bus, trailer, fire apparatus, and specialty automotive manufacturers, will be busy on heavy backlogs of orders. It means also that thousands of plants supplying parts and accessories will swing into action on parts and supplies for the manufacturers.

In the kaleidoscope of America's prospective expansion of land, air, and sea transportation, the pattern of highway transportation will be the production of current models first and the development of today's dreams later. Accompanying all this there will be a steady progress toward more and more applications of the scientific achievements and engineering knowledge of every field explored by the ingenuity of mankind.

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TRANSMISSIONS

Undergoing Intensive Experimental Work

HIGH concentration of engineering effort to improve automobile and truck transmissions is going on in Detroit and other mid-western automotive manufacturing centers. The almost forgotten Owens Magnetic gearshift has at least two counterparts in experimental stage being readied for test, and a number of simpler versions of the Oldsmobile Hydra-Matic transmission are being given the "complete treatment" by several manufacturers. Many engineers agree that motor-vehicle transmission development has been generally neglected.

CUSTOM BUILT

Motor-Cars Offer Extensive Post-War Market

SEVERAL informed motor-car distributors believe there will be an important market in "non-branded" special models of automobiles in the post-war era to satisfy the strong "fringe market." The town-car models, built on Ford chassis, were strikingly successful during the late 20's and early 30's, compared with imported European cars. Before the war the artist Peter Arno designed and had built a number of special bodies for moneyed motorists, using standard Mercury and other chassis. LeBaron, Brewster, and other custom-body builders are in business no longer, but men who know the trade are angling for this market.

Engineered Electronics

Infinitely Variable Motor Drives, Accurate Timers, Safety and Limit Switches, and Other Electronic Devices Can Improve Production Quality and Lower Costs. Application Can Often be Made to Installed Equipment, Lengthening Service Life and Increasing Output and Efficiency

By VIN ZELUFF
Associate Editor, *Electronics*

ELECTRONIC drive for machine tools has several important advantages:

(1) An infinite number of speeds in the speed range are available, instead of just a certain number of steps provided by gear changes.

(2) Changes in speed with a gear-change mechanism necessitate stopping the machine, which requires considerable time and makes a mark on the work. With electronic equipment, speed changes are made without stopping, simply by turning a small knob.

(3) Electronic motor drive is ideally suited for setting up an automatic sequence of operations where it is necessary to change the feed speed frequently, as well as for automatically regulating the feed speed to maintain a given load on the cutter motor.

TIME SAVING—A reduction in finishing time from 13½ hours to five minutes in the machining of aluminum spar beams for plane wings has been accomplished at one Cleveland aircraft plant, with the help of an electronic motor control system installed on a large automatic contour milling machine designed and built by Onsrud Machine Works, Inc.

In aircraft, spar beams are long, one-piece structural channels which run lengthwise through the wing, from fuselage to wing tip. The spar must be machined accurately to permit perfect joining of wing ribs and cap strips, and it must be contoured exactly to conform with the shape of the wing itself.

The carriage of the milling machine houses four cutter motor assemblies that finish the long spar in a single set-up despite the wide variety of cuts required. Flexible speed control of the carriage motor by the electronic drive assures that the cutters at all times are fed to the work in proper relation to the changing contours of the spar beam.

In one pass over the table, the depth of cut may increase and decrease several times, while the number of cutters entering the work may change from one to four. Such varying conditions require a change of feed to avoid overloading of the cutter motors. Moreover, a fast "skip" speed is essential to save time when no cutting at all is necessary.

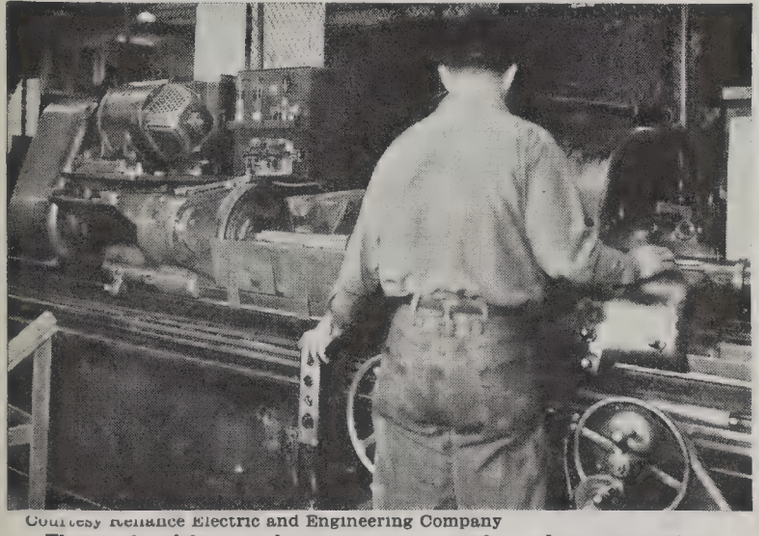
With the General Electric Thy-motrol electronic system, A.C. power is converted to D.C. to obtain a stepless speed range. The resulting infinitely variable speed within the established limits has resulted in top-speed machining of the complex spar beam at all times.

PRECISION GROOVING—A few days after Pearl Harbor, the Sundstrand Machine Tool Company was asked to build a machine for cutting a precision spiral groove in the end plates of a cartridge reel. Up to this time the best output obtainable on a special vertical mill operated by a good toolmaker was 1.5 pieces per hour. By adapting two automatic lathes for this spiral-cutting operation and using electronic control to vary the speed of the drive motor as the cutting tool moved along the spiral, output for the two machines was five pieces each per hour, and both could be handled by a single unskilled operator.

One of the automatic lathes was tooled for the right-hand spiral and the other for the left-hand spiral. On the spindle nose of each was mounted a face plate provided with a centralizing plug and manual clamps for holding the work. On the back of each face plate was a master cam with a spiral track for actuating a roller and lever arrangement for moving the tool slide in as the machine rotates.

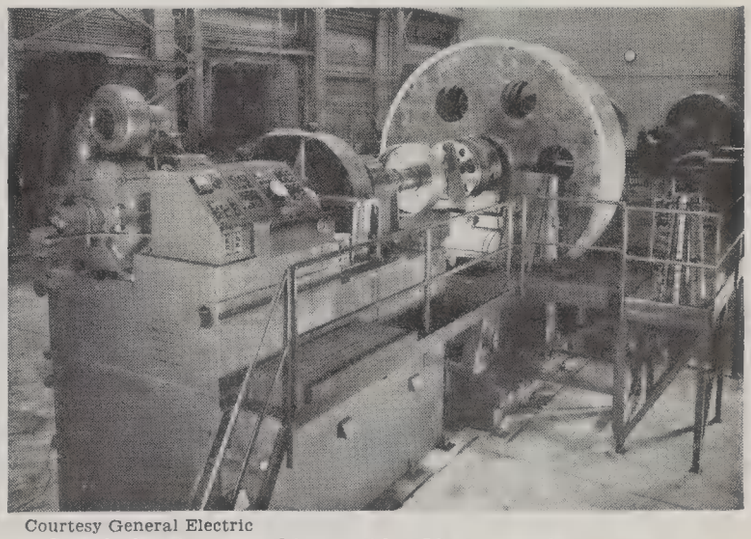
Due to the thinness of the part being machined, it was necessary to take a series of very shallow cuts until the desired groove depth of 0.07 inch had been reached. A ratchet-type in-feed device was devised to advance the cutting tool during each return stroke, and a gadget was placed on this to trip a limit switch and shut off the entire lathe when the correct depth of cut was reached.

After the operator had clamped a



Courtesy Reliance Electric and Engineering Company

Electronic drive and sequence controls reduce operation of this heavy machine-shop lathe to the utmost simplicity



Courtesy General Electric

Gear-balancing machine with 50-ton marine gear set up for test. The drive motor is electronically controlled.

MACHINE SHOP APPLICATIONS OF ELECTRONICS

- Grinders
- Metal-Working Lathes
- Milling Machines
- Slotters
- Key Seaters
- Gear Cutters
- Straightening Machines
- Bending Machines
- Spinning Machines
- Flanging Machines
- Cold and Hot Metal Saws
- Thread Mills
- Wire-Drawing Machines
- Planers
- Testing Machines
- Reversing Table Drives
- Drill Presses
- Winch Drives
- Conveyors
- Boring Mills
- Weld Positioners
- Super-Finishers
- Balancing Machines
- Automatic Screw Machines
- Honing Machines
- Molding Machines
- Punch Press Safety Stop
- Power Shears
- Sheet Grinders
- Automatic Welding Machines

blank end plate in the lathe, all he had to do was push the starting button. The lathe started turning and simultaneously the cutting tool advanced into the work from the outside at exactly the correct speed to produce the desired spiral. When the tool reached the inside of the plate, the lathe stopped, the cutting tool retracted to clear the cut, and the lathe and tool both reversed to return to starting position. The entire cycle then repeated itself automatically until the limit switch stopped the machine at the end of the last return stroke.

Maximum efficiency in this operation required constant surface speed at the cutting tool, with speed in the return direction as high as possible to reduce non-productive time. Reversals had to be smooth, acceleration fast, and speed changes gradual. All these requirements were inherent characteristics of the electronically controlled motor used to drive the lathe.

While waiting for delivery of the electronic equipment, conventional two-speed motors were temporarily installed. The production of the two machines was only six pieces an hour, with the motors running dangerously hot. After the variable-speed electronic drives were installed, combined output increased to 10 pieces an hour and the temperature rise was well within the motor ratings. The machines, complete with electronic control, cost about 10 percent more than with two-speed drives but they increased production by 67 percent. In other words, two machines with electronic drives produced as much as three machines running without benefit of vacuum tubes.

Another adaptation of this same Sundstrand automatic lathe was for turning an internal clearance radius in a propeller barrel. This was formerly a milling operation, but the cutters required resharpening so often that the manufacturer sought another method of machining. The change in the diameter of the work from start to finish was in the ratio of two to one, and best tool life and highest production was obtained by maintaining constant surface speed at the cutting tool. This was achieved with a five-horsepower motor, electronically controlled. A small cam-actuated potentiometer mounted on the carriage controls the electronic tubes in such a way that the motor starts at low speed, gradually accelerates to high speed at the end of the cut, and is then dynamically braked to stop the spindle.

TIME-DELAY RELAYS—Such machine tools as welding machines, honing machines, grinders, and molding machines have been arranged for processing, cycling, and sequencing by means of electronic time-delay relays. This type of equipment is available for timing intervals as short as 0.45 second and as long as several minutes. Nearly all such electronic devices operate over a range between maximum and minimum time settings of 20 to 1 and accuracy of repetition can be held to 1/120 second. Adjustment of the timing period is done with a single knob and the number of settings possible within the range is almost infinite. Millions of operations are possible with but a single setting and, since there are no moving parts, dependability and long life are consequent advantages.

Another use of electronic equipment in mechanical engineering should be of great interest to the safety engineer in industrial plants. Phototubes and their accompanying electronic amplifiers and relays have been applied to machines such as punch presses and molding machines. Here the interruption of a beam of light by the operator actuates the phototubes and causes the machine to become inoperative, thus avoiding accidents.

On thread milling machines, electronic drive is used to obtain a wide feed-speed range. Here, speed of operation is important and the electronic equipment provides a means for running the machine at optimum speed and making it possible for the engineer to eliminate a complicated mechanical system previously used.

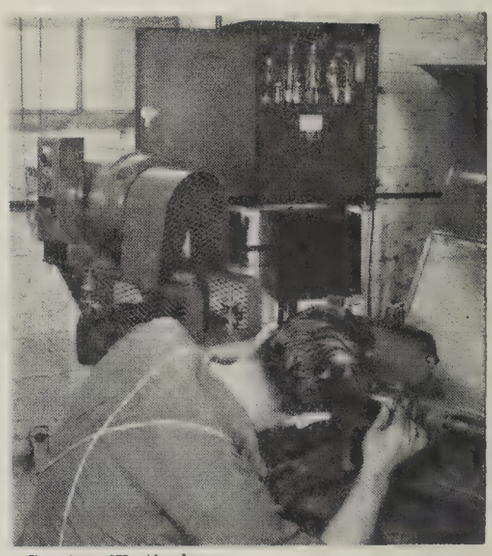
A.C. TO D.C.—The demands of many machine tools require the flexibility of speed and torque control provided only by D.C. motors. Previously this has been supplied by motor generators or rotary converters which have moving parts and require maintenance and supervision. Electronic equipment provides a satisfactory means of obtaining D.C. power at constant voltage from a mercury-arc rectifier, a device having no moving parts and requiring little supervision and maintenance.

These mercury-arc rectifiers are built in two forms—the glass tube type and the tank type with a metal casing. Such rectifiers have a greater overall efficiency than rotating equipment, particularly at light loads where the efficiency of the rectifier unit may be nearly eight times that of the motor-generator set. It has been reported that comparable operation of both systems at 85 percent of rated output permits a saving of $800 in power cost for a 300-kilowatt unit of the rectifier type. This is over and above a reasonable allowance for replacement of tubes.

Electronic drive offers many features that can be used to advantage by the grinding-machine operator. Smoothly adjustable low speeds permit designing of driving units which have a minimum of rotating parts. This reduces the vibration that is a constant source of trouble and a cause of inferior grinding.

Speed control of a grinder by means of a small device is something every mechanical engineer welcomes because the large rheostats otherwise necessary with adjustable-speed D.C. motors are difficult to mount on a machine and require a large amount of space. The electronic control uses only one or two small potentiometers.

In a grinding machine, efficiency is highest when the pressure of the work against the wheel is constant at a value corresponding to the optimum cutting capacity of the wheel. This pressure can be found, and it is possible with the electronic drive to control the infeed of the grinding wheel so that this rate of cutting will be maintained even though it is necessary to vary the feed speed to obtain it.



Courtesy Westinghouse

Electronic drive makes it possible to mount the motor at the machine, place a small control cabinet on the wall, and give the operator handy speed-change and start-stop controls

Many electronic applications have been made to the headstock drives of cylindrical grinders to turn the work at the required varying speeds during plunge-cut grinding. Without such control, the finished product may show irregularities on the surface.

Surface grinders which have a circular rotating table and a reciprocating

wheel head that is separately driven can be controlled to provide practically a constant surface speed. As the wheel approaches the center of the chuck, both the chuck rotation and the wheel head speed should be automatically increased so as to maintain within fairly close limits a constant wheel head feed movement of a specified amount per revolution of the chuck.

The application of electronics to grinding machines generally involves redesign rather than application to present design. The modernized and entirely new design gives a big reduction in the number of rotating parts and in the parts necessary to produce the desired results. This gives the user of grinding machines the advantage of wide speed ranges that will enable him to produce ground parts at the maximum production rate, finest finish, and high accuracies necessary now and in the post-war period.

ELECTRONIC BALANCING—In balancing machines, rapid acceleration and deceleration has been a difficult problem because couplings and other parts must be light in order to avoid distortion of results. Torque must be smoothly applied and limited in amount so that such parts will stand the strain. Also, acceleration and deceleration must be done quickly since the time involved is not useful.

With electronic motor control, machines with drives rated up to 200 horsepower have been provided. With these, a gradual application of torque and torque limit acceleration and deceleration is provided. The torque is not allowed to increase above the safe operating value for the machine and this maximum torque is held closely during the entire accelerating and decelerating periods.

With electronic equipment, balancing machines gain in two ways. First, the motor torque can be held to the maximum permissable value and, second, the speed adjustment is stepless and permits accurate and easy adjustment at exactly the correct speed.

By means of electronics, many old machines can be given greatly improved operating characteristics when it is impractical to obtain new machine tools. For example, use of electronic motor drives on three 30-year old Heald grinders at the Axelson Manufacturing Company resulted in improved precision finishing of hardened pump liners requiring finished tolerance of 0.001 inch. The variation in liner sizes and materials used required grinding speeds over a wide, closely regulated stepless speed range of 20 to 1 in order to secure the desired tolerance and finish.

The electronic drive used in this case consists of an electronic rectifier to change A.C. to D.C., plus a D.C. driving motor whose stepless speed is controlled by a potentiometer in the push-button station.

Physical advantages were also gained by new layouts of the machines. The three grinders were reset on a 35-degree angle with a saving in floor space of about one third. Removal of all overhead pulleys, belts, and shafting resulted in increased safety, improved illumination, and elimination of vibration.

Time study engineers at Axelson report that an appreciable saving in set-up has been effected largely by better illumination of the working area, plus less complicated controls and speed-changing apparatus on the grinders.

Thus far, the full automatic electronic control of machine-shop equipment has been confined to motors of relatively small size. Fundamentally, however, there is no reason why similar controls cannot be applied to motors of any size so long as suitable tube combinations are available for handling them. When the limit of the thyratron tube has been reached, it will undoubtedly be possible to employ the pool-type ignitron tubes in suitable circuits.

For the mechanical engineer, then, the outlook ahead in the direction of electronics is promising. With electronic drives, electronic timers, photo-electric safety and limit switches, and other tube-operated devices available at continually decreasing prices in a widening variety of types and sizes, he will find more and more frequently that he can economically specify control by electronics for improved production quality and, at the same time, lower production cost.

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ELECTRONIC TESTER

Ends Guesswork in Repairing Wires

THE GUESSWORK usually involved in locating broken wires under the insulation of extension cords and wires used on electrical appliances is eliminated when an electronic tester developed and constructed by Consolidated Vultee Aircraft Corporation is used.

In the unit, one electronic tube is connected as a self-excited oscillator operating on a frequency of about 400 cycles. The output of this oscillator is applied to the cord.

A small amount of the signal energy is picked off the cord by a metal ring through which the cord is passed. Fed to a high-gain amplifier, the signal amplitude is increased sufficiently to operate the output meter. When a break in the conductor passes through the ring, a sudden change in the meter deflection occurs and the broken spot can be quickly and accurately ascertained. Thus the necessity of cutting the cord in more than one place to locate the break is eliminated.

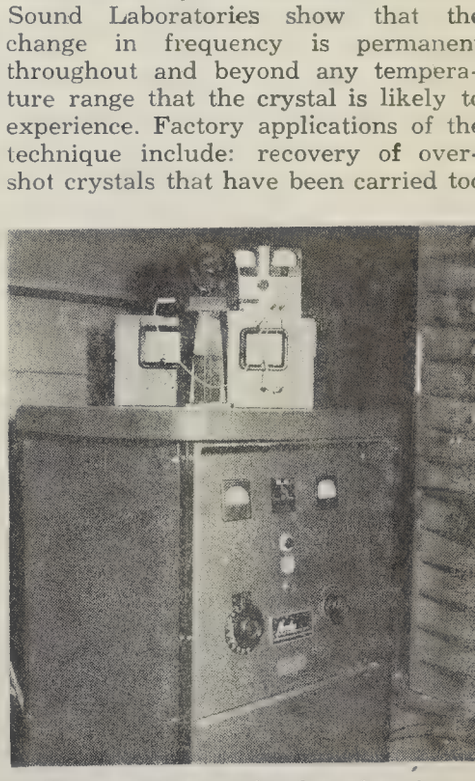
STABLE CRYSTALS

Produced by Exposure To X-Ray Beam

A NEW production technique for quartz crystals uses x-rays to adjust the delicate plates to final frequency at a rate of 30 to 50 cycles a minute. Quartz plates for the six- to eight-megacycle range can be lowered as much as three kilocycles in frequency simply by exposure to x-ray beams.

Frequency can be checked continually during the treatment, hence the crystal can be removed from the beam at the instant it reaches the correct frequency.

The x-ray equipment, developed for this purpose by North American Philips Company, employs a new high-intensity water-cooled x-ray tube. One crystal is exposed at a time. Experiments made by Dr. Frondel of Reeves Sound Laboratories show that the change in frequency is permanent throughout and beyond any temperature range that the crystal is likely to experience. Factory applications of the technique include: recovery of over-shot crystals that have been carried too



X-ray equipment for lowering frequency of quartz oscillator plates

far in finishing and hence are too high in frequency; precise adjustment of standard crystals for use in calibration and in testing; manufacture of precision crystals for frequency and time standards; precise adjustment to final frequency without the possibility of further aging.

FLUTTER RECORDER

Is Light, Compact, and Simple to Install

PRESENT knowledge of the flutter of airplane parts has been gathered from experiments on the ground and in flight. For exhaustive study in the air, equipment weighing about 500 pounds has been used. Installation and tests by this method required about two weeks.

A new flight vibration recorder uses electronic tubes and is light enough to be held on the lap of the observer. Installed and put into use in a few hours, it is also useful in the study of vibration in motor mounts, cowling and small accessories. Velocity or accelerometer type pickups can be placed at many points about the plane and two of these can be operated simultaneously. A selector switch permits other points to be studied during the same flight. The electronic unit contains its own batteries, amplifier, electronic switch, and cathode-ray tube as well as a camera to photograph the oscillograph record.

Engineers and Wings

Co-Operation Between Aeronautical and Mechanical Engineers Has Made Possible Such Strategic Airplanes as the Superfortress and Other Military Marvels. It will Bring to Post-War Civilian Flying a Like Measure of Success in Conquering the Problems of Flight

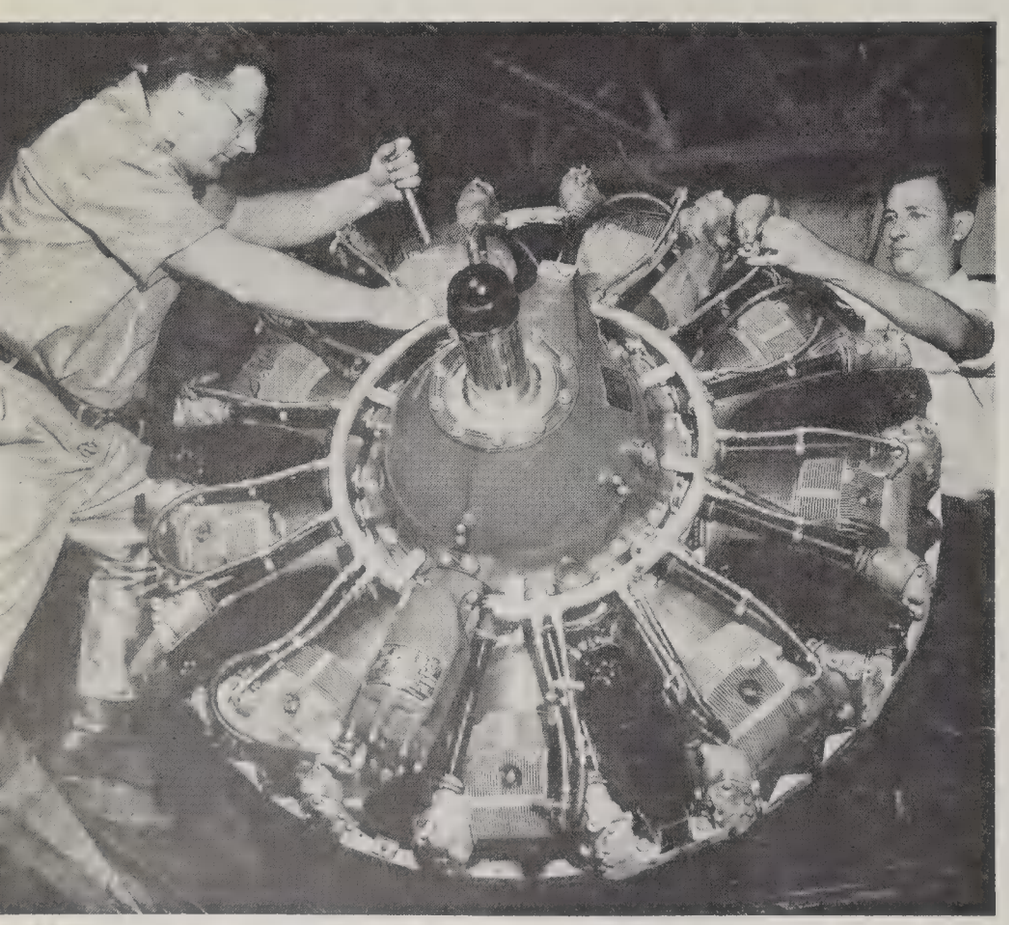
WITHOUT high development of mechanical engineering, and its continuous support, modern aviation would never have been possible. On the other hand, aviation has, by its scientific research, led directly to many refinements and advances in the theory and practice of mechanical engineering.

The airplane power plant is the point where the immense achievements of mechanical engineering attain their highest concentration in the science of aviation. Hence a survey of the relationship between the two fields can best begin with a consideration of the contributions of mechanical engineering to the airplane engine. The prime mover in aviation has grown in power and complexity from the early days of the Wright brothers until it is today a remarkable unit capable of developing 2200 horsepower with its weight running scarcely more than a pound per horsepower. Other aviation engines have an even lower power/weight ratio.

For many years the airplane engine has not departed from the classical principles of the four-cycle internal combustion engine, although it has been improved rapidly in compression ratio, refinement of materials, strength design, and better cooling. There is no comparison as regards specific power and efficiency between the airplane engine and the automobile or motorboat engine.

While in the early days of aviation the internal combustion engines used were designed largely by mechanical engineers with automobile experience, aeronautical designers have now far outstripped the originators. It is probable that in the post-war period motorboat and automobile engines will follow airplane practice. Today, the conventional four-cycle engine is losing ground. A greater knowledge of thermodynamics, coupled with vastly improved materials capable of withstanding high temperatures under stress, all enlivened by a burst of new ideas in both mechanical and aeronautical thought, have changed the whole situation.

It may confidently be expected that the development work of many years in the building of airplane superchargers will be succeeded by the construction of gas turbines running possibly to 5000 horsepower and causing something like a revolution in the aircraft power-plant. The turbo-jet engine, in which a compressor, driven by a gas turbine, compresses fuel and air so that they burn to give a jet of great speed and high power to drive the airplane forward, will supplant the conventional power-plant and propeller in planes with speeds well over 500 miles an hour. At the same time, a return to mechanical industry in the development of the aircraft turbine will be made. Undoubtedly the success of these prime movers will fire with renewed ambition engineers concerned with railroads and surface vessels. Gas turbines may soon be propelling both railroad trains and sea-going vessels.



Lighter and more powerful engines are continually being made as a result of the joint efforts of mechanical engineers and aeronautical experts. This new Wright Cyclone engine weighs only .97 pounds for each of its 1350 horsepower

APPLIED KINEMATICS—There is scarcely a single aspect of kinematics that is not utilized to the full in aviation. A typical application is that of geared combinations of various types and design. In the airplane engine, where as much horsepower per pound must be developed as possible, every effort is made to increase the engine's revolutions per minute. On the other hand, a propeller which revolves too rapidly loses efficiency (because the tip speed then approaches the speed of sound) and also makes far too much noise. Hence it becomes essential to gear the propeller down, and here applied kinematics comes into play.

Gearing down the propeller would seem at first to be quite a simple problem. Why not use a single reduction gear, of the herring-bone type, with a big gear on the propeller shaft mesh-

ing with a smaller gear on the engine shaft? If this apparently simple solution is applied, the thrust line of the propeller is placed to one side of the axis of symmetry of the engine so that complex stresses are produced in the crankcase.

The airplane-engine designer therefore borrows the system of planetary reduction gearing from the applied kinematics of the mechanical engineer. An internal-tooth drive gear is splined to the crankshaft and drives four or five planetary gears carried by a pinion cage, itself splined to the propeller shaft and meshing with a fixed gear bolted to the crankcase. This is a typical but not a universal arrangement. Because a number of "planets" revolve around the fixed "sun," the load produced by the tremendous power of an aircraft engine is divided into several parts and thus reduces the strain on the gear teeth. The planetary gear is more complex than the single gear system, but it avoids eccentricity of thrust and is probably more compact and lighter.

If the aeronautical engineer has borrowed from mechanical engineering in using gear trains, he has also given much in return. To provide adequate strength and minimum weight, aircraft engine requirements have speeded the development of heat-treated and hardened alloy steels. Also, the great engine builders such as Wright Aeronautical and Pratt and Whitney have insisted on a degree of accuracy and efficiency in spur and bevel gearing which the gear-making industry had previously thought impossible.

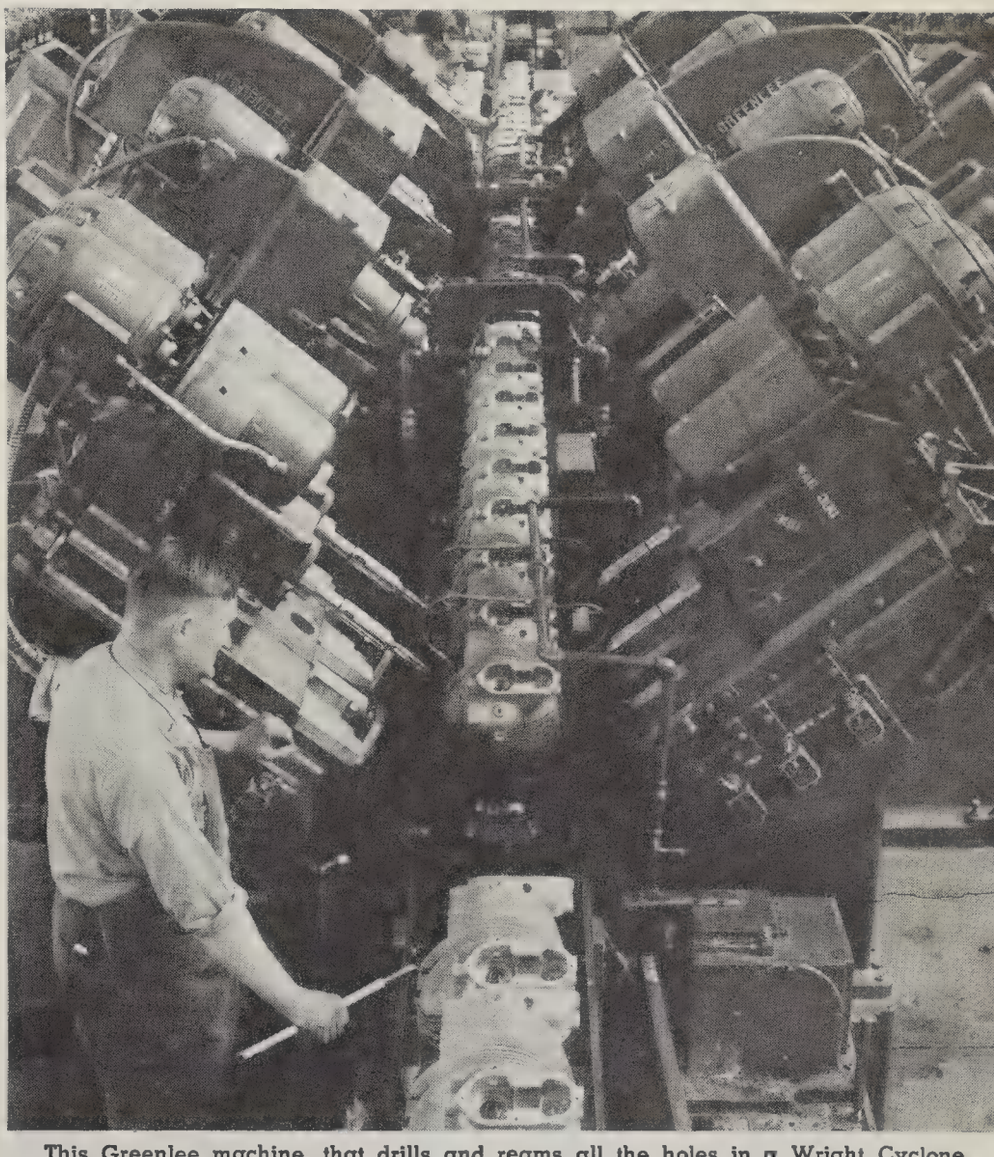
The opening and closing of the intake and exhaust valves at the proper point in the cycle is closely connected with the efficiency of a four-stroke cycle engine. Because the aircraft engine works at high speed, the valves must be opened and closed quickly and held wide open for a large part of the total time. But to keep down acceleration forces and spring tension, the valves should be opened and closed gradually. This contradiction in requirements and the necessity of designing cam contours that are neither difficult nor too expensive to produce, makes cam design difficult and fascinating. Aviation here borrows all it possibly can from the mechanical engineer.

VERTICAL FLIGHT—A new type of aircraft is now in the forefront of public attention. No aerodynamicist, however skilled or learned, could build it unless he had the mechanical engineer to back him. This is the helicopter. The aircraft engine is most efficient when turning over rapidly, but the lifting propeller of a helicopter must revolve rather slowly to give a powerful thrust per horsepower. A 10 to 1 reduction must be achieved in small compass, with little weight and, above all, with the highest possible efficiency of transmission.

In the helicopter, efficiency of transmission may make the difference between hovering ignominiously 20 feet or so above the ground and the ability to climb straight up to a height of several thousand feet. Hence the helicopter constructor has called on the finest art of the mechanical engineer to secure the best possible gears: spur gears cut with greatest accuracy, or the wonderful spiral bevel gears, which are so smooth in operation because of their gradual engagement.

Another necessity of the helicopter is a clutch which will engage automatically yet slowly when the engine has reached certain revolutions per minute. The helicopter engine must idle and warm up before flight. If the clutch were then thrown in suddenly, a violent shock would be imparted to the rotor blades, with possible damage. Therefore the mechanical engineer has been asked to design a clutch with balls subjected to centrifugal force acting against a spring, bringing the clutch into play at a certain predetermined speed, with the clutch allowing a certain amount of slip before full engagement.

Still another mechanical problem of the helicopter is that of the over-running clutch. When the engine fails, the rotor must continue to rotate in the same direction as before; that is, to autorotate. To have autorotation, two things are necessary: the pitch of the rotor blades must decrease quickly (either by manual control or automatically) and the rotor must be disengaged from the remainder of the transmission. It is for automatic disengagement that an over-running clutch is required. Such clutches are being designed on the wedge principle, with rollers between an inner and an outer ring, and a plane cam surface on the inner ring. With the inner ring splined to the transmission drive, the rollers are wedged to the outer ring when power is applied. When the engine fails and the outer ring tries to drive the inner ring, the rollers are un-wedged, engagement between the two rings ceases, and the rotor is free for autorotation.



This Greenlee machine, that drills and reams all the holes in a Wright Cyclone cylinder head, strikingly illustrates how successfully mechanical engineering responded to the demand for machine tools to speed up the output of warplanes

HYDRAULICS AID FLIGHT—Applied hydraulics is yet another branch of mechanical engineering upon which airplane designers have drawn heavily. The advantages of hydraulics in power transmission are light weight, controllability, and low inertia of moving parts.

The airplane hydraulic system is more complex than that in automobile brakes and involves the use of a reservoir and a directional control valve. The reservoir is necessary to take care of change of volume of the fluid with change in temperatures. The directional control valve or "four-way valve" is required in a system that must operate in two directions.

Airplane hydraulic systems have been developed which can be applied to brake actuation, retraction of landing

gear, actuation of wing flaps, moving of gun turrets and, in general, to any task where reliable and rapid application of power is desired. It is certain that applied hydraulics is of as much service to aviation as applied kinematics.

And here again reciprocity exists. The special needs of the airplane have introduced into hydraulics an exactness and rapidity of control hardly thought of before. In airplane hydraulic systems, where lightness is sought above all, pressures of as much as 3000 pounds per square inch have been introduced, with the lightness and compactness of the new equipment astonishing hydraulic engineers accustomed to more conventional design.

COMFORT IN FLIGHT—In comfortization of aircraft, aviation has drawn heavily on heating, ventilating, air-conditioning, and air-compressor engineering. From the ventilating engineer, aircraft engineers have obtained data on the quantity of air required by passengers. They have also learned other fundamental requirements of air supply such as humidity control, constant circulation, reduction of carbon dioxide, proper distribution of both humidity and heat, and so on.

The comfortization of aircraft has also applied principles of heating engineering in utilizing exhaust heat of the engine for building adequate heating systems which are not excessively complex and at the same time are free from the danger of introducing exhaust gases into the cockpit. It is probable that in the post-war era airplane design will include heating of wings and tail surfaces to prevent icing-up; electric heating of many accessories such as pitot tubes to give speed indications; and the use of exhaust-gas heating with due precautions for use in the cabin. Finally, on air transports there will be almost universally a system of supercharging the cabin for altitude work.

The mechanical problems involved in pressurizing will deal first of all with the cabin supercharger. This is nothing but the mechanical engineers' air compressor. Automatic controls will be provided for maintaining the pressure inside the cabin at the equivalent of an altitude of about 8000 feet. Safety devices will help to maintain pressure in case the compressor fails, and methods of sealing the cabin will be used even where multiple instrument and control lines pass through the cabin walls.

UNIVERSAL STREAMLINING—Not so very long ago, railroad engineers had queer notions of resistance to motion. The writer has seen formulas in which the ground friction, which is roughly constant and proportional to the weight of the train, was lumped together with the air resistance which varies with the square of the speed. Applied aerodynamics has now penetrated into mechanical railroad engineering and substituted correct conceptions of resistance.

Also not long ago, railroad engineers were likely to neglect completely the question of air resistance. They did not seem to realize that at 70 miles an hour, two thirds of the entire power of the locomotive was expended in working against the air. It is under the stimulus of the constant example of streamlined aircraft that railroad men have gradually accepted the streamlining of locomotives and coaches.

There is still another way in which the airplane has benefited the mechanical engineering of the railroads. In the airplane, almost since its inception, there has been a striving after lightness of construction. This resulted, later on, in the use of light, high-strength aluminum alloys and stainless steel. At all times it demanded careful calculation of stresses and strains. In the construction of railroad equipment there never was striving after lightness. Cheap metals were deemed the best metals, and there was no attempt at structural analysis. Safety was secured by following tradition and strength of construction by brute-force of masses of material. The result was the strong but exceedingly heavy coach of American railroad practice, whose unnecessary weight wastes so much power. In the design of the modern streamliner, on the other hand, whether in aluminum or steel, the most refined methods of aviation stress analysis have been studied and applied.

The automobile has similarly benefited from aviation. America's cars are already far better streamlined than in the early days. In post-war days they will follow aviation practice as regards lightness and the liberal use of aluminum and magnesium. Their engines will imitate aircraft engine practice in being lighter for a given weight, and in having higher compression ratios.

Aviation has also benefited another branch of mechanical engineering far older than the automobile or even the railroad—the production of power from wind energy. For centuries, the windmill remained unchanged. Even the advent of the industrial revolution left windmills of small power, clumsy blades, clattering shifts into the wind, and clumsy gearing. Their use was restricted chiefly to isolated farms. Aviation has changed the whole outlook for the windmill. Windmill theory has been completely changed by analogy with propeller theory: for inefficient blades the best airfoil profiles have been substituted. Ideas borrowed from the variable-pitch propeller have brought into being mechanisms designed to change the pitch of the windmill blades in sudden gusts so as to limit airloads and prevent disaster. The art of building cantilever wings has given engineers the confidence that they can build windmill blades of enormous radius. The war stopped windmill development, but there is every reason to believe that the post-war period will see a number of ambitious undertakings in the building of auxiliary power plants based on the capture of wind energy at selected locations.

All in all, the writer is convinced that mechanical engineering has benefited almost as much from aviation as aviation has benefited from the activities of the mechanical engineer. American engineers, industrialists, and publicists might well keep in mind that excessive specialization is harmful. Let them remember that all branches of American industry and applied science are likely to benefit from cross-fertilization.

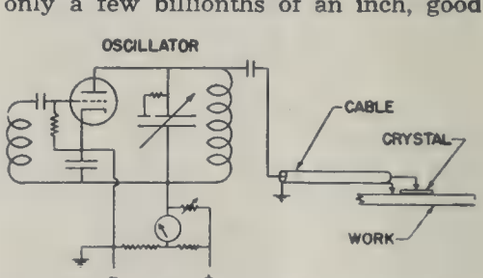
THICKNESS MEASUREMENT

Applied to Airplane Parts Where One Side is Inaccessible

In the inspection of highly stressed airplane parts, it is highly important to check the thickness. Sometimes this becomes a difficult task when the inner surface of the wall is inaccessible—as, for example, the wall of a hollow steel airplane propeller. To measure by the echo method of sound reflection, or by the use of short-wave reflection as in "radar," might theoretically be feasible, but would mean intolerable complexity in practice.

Wesley S. Erwin, in a paper presented before the Society of Automotive Engineers, describes a supersonic contact instrument for thickness measurement which has been developed in the research laboratories of General Motors. It is as accurate as it is ingenious and simple. The Sonigage, as it is called, does not measure time intervals but rather the frequency of oscillation at which the metal is set into resonant vibration. This frequency, on appropriate calibration, gives a correct indication of the thickness of the work.

The circuit of the device is shown in the sketch. A small flat piece of quartz crystal is placed against the metal wall whose thickness is to be measured. If a high frequency potential is applied to the quartz plate faces, the crystal will change thickness rapidly at that frequency. This forced mechanical vibration is transmitted to the material by placing one face of the quartz plate in contact with it. Since the amplitude of this high-frequency motion is only a few billionths of an inch, good coupling must be provided between the crystal and the work by an oil film.



Checks thickness by resonance

A power output meter serves to indicate the resonant frequency of the work. This resonance point is very sharp and if the oscillator is detuned as little as 1 percent, by changes in metal thickness, the indicated power amplitude is greatly reduced. Thus a quick glance at the indicator will tell the inspector whether the particular part is of the right thickness or not.

Backbone Of Engineering

Continuing Development of Metals and Alloys is Giving the Mechanical Engineer New Tools With Which to Work. What Metallurgy is Doing Now Will Have a Direct Effect on the Progress That Will Be Made in the Future. New Materials Mean Better Machines and Prime Movers

IT DOES not take a metallurgist to perceive that machines and engines are largely masses of metal in motion and that there are many different metals in a particular machine. But the job of selecting or developing the best alloy for each part or service—the right material for a bearing, the correct steel for some reciprocating shaft, or the most durable metal for the base—requires not only an intimate knowledge of materials and a thorough understanding of machines but the combined wisdom of Solomon and the patience of Job as well.

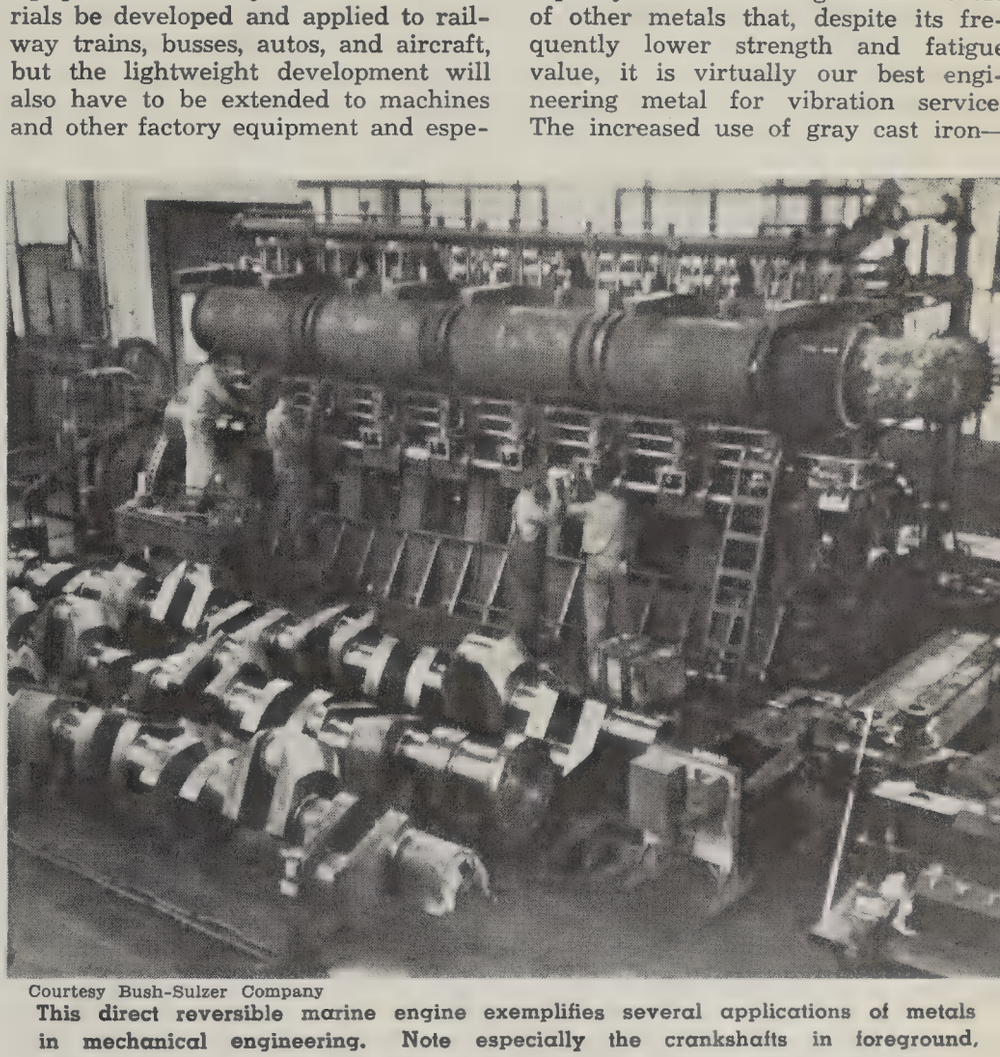
Mechanical engineering has always depended on metals. But to an even more significant extent its recent progress has rested directly on metallurgical progress. Limitations of power, speed, loading, and temperatures of mechanical equipment today are limitations imposed by the existing materials and the maximum performance obtainable from them. This being the case, what does the future hold in new alloys and new metal-working methods that may strike away the bonds of the recent past and permit the design of faster and more powerful machines and engines than those in common use up to now?

Looking at the problem from the engineering rather than the metallurgical point of view, it is observed that the necessary improvements must come from the following directions: (1) Ability to withstand vibration, repeated stressing, or rapidly reversed loading—broadly called fatigue endurance or fatigue strength—required in such parts as Diesel engine crankshafts, airplane propellers, springs, bolts, machine-tool bases, automotive bearings and rocker arms, axles of all types, and so on. (2) Surface smoothness and wear resistance, needed in bearings of all kinds, automotive and aircraft cylinder walls and pistons, machine tool guides and ways, scarifier blades, valve seats, and the like. (3) Toughness and shock resistance—technically known as impact strength—to withstand pounding in service received by things like ball bearings, forging hammer dies and blocks, automotive connecting rods, valve stems, shock absorber links, aircraft landing gear, railway car couplings, rail ends, axles, and thousands of large and small machine parts that strike each other in service.

There is, in addition, another basic property that must be possessed to a greater extent by some new or future materials than it is by any metals now in common use, if mankind is to enjoy the full possibilities of mechanical engineering design. This is resistance to the effects of high temperatures (loss of strength and rapid oxidation). It is the chief requirement for materials used in steam and gas turbines, boilers, furnace and heater parts, oil refining and other process-industries equipment, as well as brake drums, thermostatic and pyrometric elements of various types, internal combustion engine valves, exhaust manifolds, and so on.

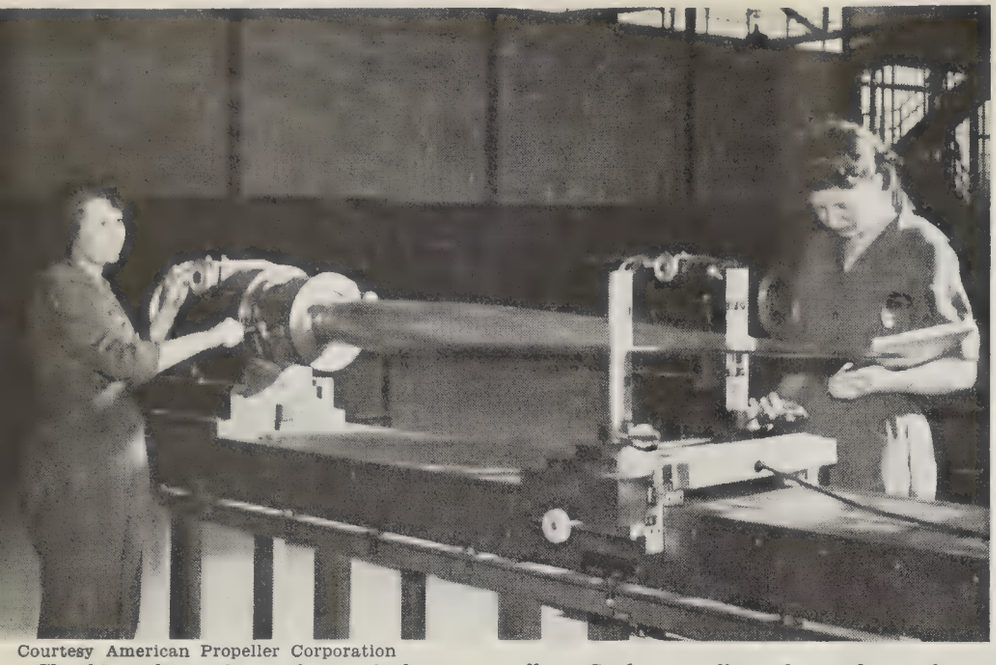
Further, the mechanical equipment of the future will require metals and alloys with even better strength/weight ratios than those now serving in machines, engines, and transportation equipment. Not only must such materials be developed and applied to railway trains, busses, autos, and aircraft, but the lightweight development will also have to be extended to machines and other factory equipment and especially to their load-bearing parts if power increases per unit of equipment weight are to be realized.

FATIGUE FAILURES—How is the battle faring with vibration or repeated-stress failures? Here, indeed, progress has been astonishing! In the first place, a once-obscure property of materials—damping capacity or the ability of a material to absorb and thus "dampen" vibrations rather than to transmit them freely—has been investigated and it has been found that certain metals possess it to a degree that has invited new engineering respect for them. Foremost among these is the once-lowly gray cast iron, whose damping capacity is so much higher than those of other metals that, despite its frequently lower strength and fatigue value, it is virtually our best engineering metal for vibration service. The increased use of gray cast iron—



Courtesy Bush-Sulzer Company

This direct reversible marine engine exemplifies several applications of metals in mechanical engineering. Note especially the crankshafts in foreground, parts of which must be simultaneously resistant to wear, fatigue, and impact



Courtesy American Propeller Corporation

Checking dimensions of an airplane propeller. Such propellers demand metals that are light and strong, fatigue resistant, and which can be precision finished

and especially of the high-strength varieties now available—is one way in which post-war machine designers will reduce vibration and thus cut down the number of fatigue failures that may occur in their equipment.

Materials of high damping capacity like cast iron tend to eliminate the vibration that leads to fatigue failure. The greater attention in the fatigue sphere, however, has been directed to making materials and machine parts more resistant to whatever vibration *does* occur, or to repeated stressing or alternate pulling and pushing of a part. Since this is an obvious and major problem in the operation of guns, it is no wonder that the war period has witnessed enormous strides in improving the fatigue properties of materials.

These strides have not involved the development of new fatigue-resistant alloys. Rather, they have been in the direction of the treatment or protection of metal surfaces in various ways, primarily to aid in preventing the formation of even the tiniest fatigue crack. In the heat treatment of parts intended for fatigue service, controlled atmospheres, salt baths, or quick surface-hardening methods are employed to avoid—in some cases, even to correct for—decarburizing the surface, since a decarburized surface is highly susceptible to the formation of a fatigue crack.

Scratches, tool marks, identification stampings, and the like are scrupulously avoided in airplane wing coverings, propeller blades, overhead power-line cables, machinery shafts, bearings, and so on. From such small beginnings do great fatigue failures grow. Surfaces of parts are highly polished in proportion to the fatigue service they are expected to undergo; occasionally they are electroplated to improve their endurance, but some types of plating seem to be better than others, while certain electroplates are definitely harmful.

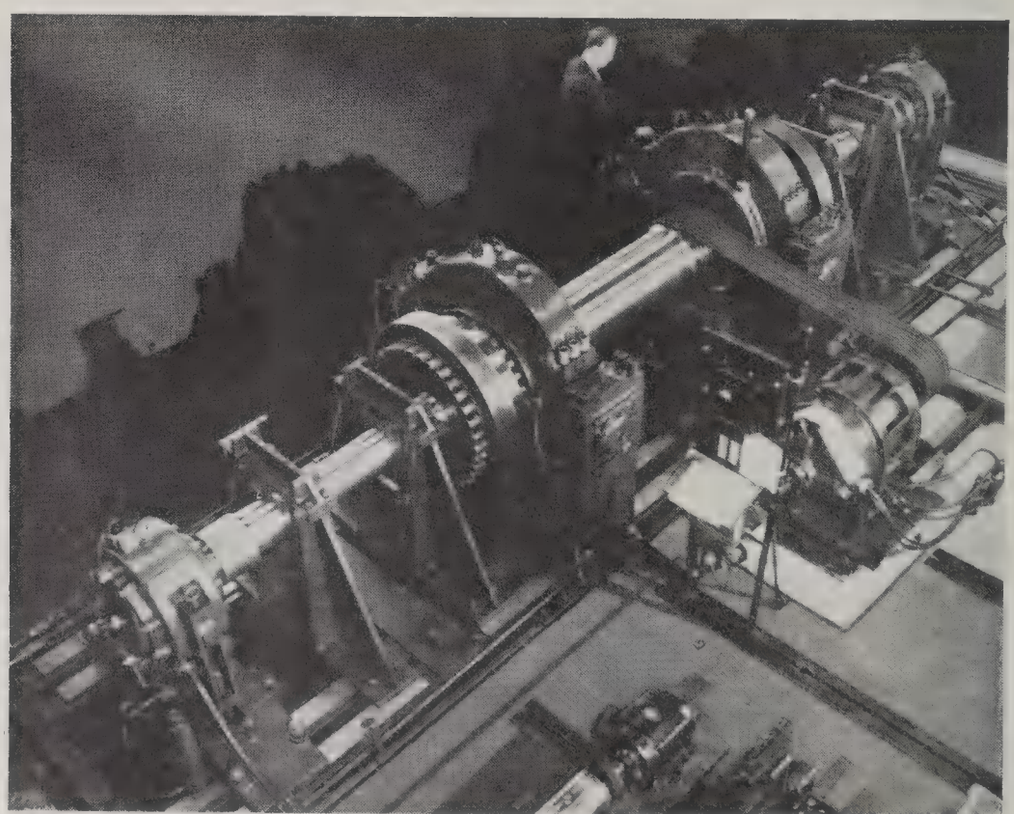
The most spectacular method of improving the fatigue strength of a metal part is shot peening, alluded to in Scientific American, January, 1945, page 14. By this mass-production treatment, castings, forgings, and other parts are enabled to resist from two to ten times the number of stress reversals that the un-peened part could withstand.

Fatigue failures are believed by many engineers to be the most common cause of breakdown of mechanical equipment. Their reduction will obviously mean better and longer service from our machines. In a broader sense, however, our new ability to design parts of thinner sections means that greater power can be built into machines of given weight than has been possible heretofore.

BEARING PROBLEMS—The familiar machinery bearing is a metal product that is required to undergo considerable fatigue stressing in service; it is also a first-class example of the need for metals having high smoothness and resistance to wear in continued metal-sliding-on-metal service. Mechanical engineers, faced with this problem from the first moment a wheel turned, have utilized a variety of materials for so-called plain bearings. The old standbys include lead-base babbitts (lead-antimony-tin alloys), bronzes and leaded bronzes, tin-base babbitts (tin-antimony-copper alloys, widely used in the automotive field in normal times), copper-lead alloys, cadmium-base alloys, cast iron, and "oil-less" or self-lubricating bronze or iron materials.

Bearing service is a combination of many factors, the most important being resistance to galling, conformability, embeddability, fatigue strength, corrosion resistance, and ability to be bonded to a backing if required. The metals listed in the preceding paragraph possess these in varying degrees: there is no perfect bearing metal. Not so long ago, engine and machine designers were actually forced to compromise their speed, power, and lubricating oil relationships. No one of the foregoing bearing metals could measure up simultaneously with respect to (a) resistance to seizing at the temperatures reached with higher loading, (b) fatigue strength, and (c) resistance to corrosion by the modern high-compression-engine oils.

But the war years have evolved and gained acceptance for new bearing metals that remove some of the barriers once considered inevitable by engine designers. Pure silver bearings and silver-lead alloys (either cast or plated and heat-treated) have found an important place in aircraft engines and are certain to be widely used in post-war trucks, motor-cars, and machines in general. They have superior fatigue strength and excellent corrosion resistance. Indium-plated bearings are now widely used and are promising



Courtesy Timken Roller Bearing Company

A locomotive axle-testing machine which simulates conditions that will pertain at operating speeds of up to 150 miles an hour. Few services required of metals are so severe as those demanded by axles for high-speed transportation

post-war prospects for similar reasons.

A special bearing consisting of lead-base babbitt impregnated into the pores and over the surface of a copper-nickel matrix sintered by powder metallurgy methods onto a steel back has been used by at least one automotive company. It has been found that the combination of backing strength, bondability, fatigue strength, and corrosion resistance which this bearing metal provides is a great improvement over those previously used. Finally, self-lubricating powder metallurgy bearings made with tougher, stronger iron-copper materials offer promise of use in heavy-loading service once considered too severe for the conventional sintered bearing.

TOUGHNESS—To most engineers, the outstanding characteristic of metals that leads to their use in machinery and engines is their toughness—their ability to withstand pounding or sudden shock or rapidly applied pressure without breaking. Certain types of wrought steels and copper alloys are among the toughest metals, with cast metals as a group weaker than those that are rolled or forged.



Machines and engines throw metal against metal in many places; thus, wear tests such as those carried out on this machine at Westinghouse are essential to proper choice of materials for such applications

A common design situation in the past was that in which castings were employed for certain machine parts because the shape of the parts precluded production as forgings, or because only the casting method would meet the speed or cost specifications of the job. This was done despite the limitation on the speed or power of the resulting machine necessarily imposed by the relatively lower toughness or general strength of the cast materials with which engineers have traditionally worked. Mechanical engineering of the future will not be so limited, however, by virtue of certain recent developments. Notable among these is the growing availability of high-strength castings on one hand and the perfection of methods and equipment for economically forging large and complicated parts on the other.

Improvement in the properties of castings has been accomplished variously: Gray iron castings are now scientifically processed to give impact and tensile strengths three or four times those available 15 or 20 years ago; centrifugal casting methods yield copper alloy (especially aluminum bronze) and steel castings comparable in toughness to the corresponding wrought materials; modern heat-treating methods have elevated steel castings to the status of a first-class engineering material.

Similarly, war-time developments in the forging field hold much significance for post-war mechanical engineering. Forging machines and presses have been developed to manufacture aluminum and steel forgings of sizes previously considered impossible. The result is that many aircraft engines now are 15 to 20 percent more powerful or faster because their cylinder heads are now strong aluminum forgings instead of the conventional castings. Forged steel cylinder head and barrel units make our PT boats faster and deadlier than if the unit were a casting or an assembly job.

The impact strength of metals decreases rapidly as temperatures are lowered. For this reason, the development of alloys that would not become dangerously brittle at the sub-zero temperatures which supercharger intake parts encounter has been a major war-time problem and achievement. The materials that maintain their toughness best at low temperatures are the austenitic or stainless steels and the copper alloys as a class. Nickel-alloy steels have always been superlative in this respect, and several have been assigned war-time low-temperature uses that are ideal preparation for a bright post-war career in the expanding refrigeration and air-conditioning field.

BRILLIANT ACCOMPLISHMENTS—Bright as are these advances, metallurgy's shiniest contribution to the expansion of mechanical engineering design horizons, in the opinion of many, is its solution to the high-temperature problem that up to now had blocked the development and efficient use of the ultra-compact and light gas turbines and related power equipment. The gas turbine, based on the use of hot combusted fuel gases to operate an air compressor for combustion-air and then to deliver the surplus power for useful work, is an efficient prime mover only when it can run at temperatures above 1300 degrees, Fahrenheit. Up to now there have been no alloys in general use capable of withstanding such temperatures for an economically reasonable period.

Today, however, gas turbines or their derivatives are serving as super-chargers in fast stratosphere-flying aircraft, for jet-propelled planes, and for ships of certain types. Their future for powering such things as locomotives and generators, and developing more power per unit of space or weight than by other means, is bright indeed. And this is all because new alloys and forming methods were developed and used for the impeller buckets and blades and for the drive shafts that reach extremely high temperatures. The alloys—still a military secret—must also be balanced and stable as to thermal expansion characteristics and for some jobs must be resistant to the destructive effects of *cold* at one end of the system as well as of *heat* at the other.

LIGHT WEIGHT—Perhaps the most obvious of today's metals developments which will have a strong influence on tomorrow's mechanical engineering is that of light weight. Aircraft, railway trains, motor vehicles—in fact, anything that moves or must be lifted—are better if lighter. There is now emerging a specific group of either high-strength or low-weight materials (aluminum alloys, magnesium alloys, stainless steels, "low-alloy" steels, plywoods, and so on) that are going to be the foundation for an era of light-weight design whose scope today can merely be guessed. Since this development will be featured in our appraisal next month of metals in the railroad field, we'll do no more than mention it here.

Non-metals are certainly increasing their applications as materials of construction in engineering equipment especially in the transportation field. But it will be many many years before they will seriously threaten the position of metals as the backbone of mechanical engineering, able to withstand the terrific pounding, twisting, pushing and pulling, abrading, and heating and cooling to which machine and engine parts are characteristically subjected.

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FAST HEAT

Made Possible Through New Gas Heating Process

STEEL heat-treatment is being advanced at a rapid pace through the development and increasing application of a new gas-heating technique variously referred to as high-speed heating, patterned combustion, "hell-hole heating," and so on. This process is not only reducing heating time on many jobs but also opening up, for gas heating, applications once reserved for torch and induction-heating equipment.

In high-speed heating, pre-mixed gas and air are fed to radiant ceramic cup burners so designed as to develop and hold extra-high temperatures and concentrated heat in a relatively small space. In a particular installation, large numbers of these burners or chambers are employed, the result being an extra high-temperature "head" delivering heat to the work at such a rate that the time to heat it is a simple function of its own thermal conductivity.

Using this technique, a six-inch bar of steel can be brought up to 1800 degrees, Fahrenheit, in 15 minutes—three times faster than has been heretofore possible. Stainless steel tubing 1/16 inch thick is fully annealed in five seconds. Large installations are now in production on surface-flowing of electro tin-plate and on heat treatment of steel castings, in addition to many applications to the continuous heating of bars and tubes.

Partners In Production

Mechanical Engineering Looks to Chemistry, Chemistry Looks to Mechanical Engineering, and Between the Two They have Produced an Industry Second to None in the World. Chemical Production Requires Equipment that Can be Provided Only by Close Co-Operation With Fabricators

By F. J. VAN ANTWERPEN
Associate Editor, *Industrial and Engineering Chemistry*

MUTUAL dependence is an axiom of American industry. Total war has proved completely that each industrial unit is dependent upon the production and products of another and that the failure of one portion of the production machine means the failure of the whole. Particularly is this true in the case of chemistry and mechanical engineering. Every chemical used in this country is made in apparatus that came out of fabrication shops scattered all over the nation.

Once, in walking through a huge gasoline cracking plant that had been constructed during the period of the most hectic materials- and facilities-shortages of this war, I was surprised to see that the heat exchangers all bore metal tags proclaiming their maker to be one of the large manufacturers of rayon materials. Never to my knowledge had this particular company been in the business of building chemical equipment.

My inquiries were answered promptly by the statement that when it had come time to place orders for equipment necessary for the gasoline plant, all regular channels were so busy with other important war orders that delivery would be delayed many months. The rayon company had a large machine shop well qualified to make any type of equipment and they were given the orders and plans for making the hundreds of heat exchangers that are necessary in producing high-octane gasoline.

This illustrates the important point that no chemical can be made without suitable equipment. It also helps to prove that the science of mechanical engineering is basic and that its principles can be successfully applied once the fundamentals are determined. In this instance, a firm of engineers, designing and building a chemical petroleum plant, could turn over an order for mechanical equipment to a producer of rayons—and because of the close co-operation between the world of theory and engineering, the results are all that had been originally planned.



Glass-lined tanks and easily cleaned rubber hose help keep breweries sanitary

CHEMICAL-MECHANICAL GROWTH—The story of the growth of the American chemical industry cannot be separated from the efforts of the mechanical engineer in creating and building new equipment. The industry that supplies the tanks, pumps, reactors, autoclaves, filters, and hundreds of other specialized and intricate pieces of apparatus is a great American business in itself.

When World War I burst upon us there was a great demand for chemicals made domestically. Not only was American industry forced to expand, because of the necessity of creating an entire organic chemical industry, but the demand for heavy chemicals, such as sulfuric acid, was increased many-fold. To make all these products, new machinery and corrosion-resistant vessels were necessary. Prior to that, much of our chemical industry was carried out in foreign equipment by processes written by foreign chemists. Suddenly the demand was made not only for a home-grown chemical industry but for an industry using home-produced equipment. Designs in many cases at that time were copied from already existing machinery, and the materials of construction were the ones most commonly available—iron, steel, some nonferrous materials, and some alloys. Ceramic materials bore the brunt of construction designed to prevent corrosion. In many cases their fragility caused much delay and loss. But America came through. Upon the fundamentals that were then laid down, a mighty American industry has been organized.

UNIT OPERATIONS—The chemical engineer has been of prime importance in this development. Using his training in the fundamentals of chemistry, and borrowing heavily from the technique of experimentation and the resolution of experimental data into basic laws, he has evolved the science of chemical engineering into a series of functions known as unit operations. These in most cases can be reduced to mathematical expressions.

The basis for equipment design has been removed from the realm of experience alone and the design of a working plant is no longer merely an art. An engineering problem today is reduced to the operations that must be performed, and usually the actual calculations that predict the performance

of any piece of equipment can be made from the basic experimental data obtained through laboratory study.

Experience in most cases would be a bad teacher. The mere physical facts involved, such as the location of the plant, would throw off any calculations that were made on the basis of a plant that worked somewhere else. The change in location would involve such fundamental data as the mean temperature of the cooling water, the hardness of the water and its scaling characteristics, the altitude, and the type of fuel available. It has become necessary for the engineer to take the lead of the chemist in this respect, and rely on experimental facts for the design of equipment. If the basic data are available, most of the problems peculiar to a location or new design are easily solved.

Another important point seldom realized in general considerations of the engineering sciences is the interchange of information and techniques. Thus one of the largest manufacturers of process equipment designed and discovered the methods that resulted in the cladding of steel plate with other more chemically resistant materials.

An important contribution to the mechanical engineer is the introduction of an amazing number of new materials of construction. The use of plastics is too well known to require more than passing mention. The chemist has supplied more and better alloying materials—an outstanding example is molybdenum, a metal that has helped in this war to relieve shortages forced upon us by the cessation of imports.

MAKING MAGNESIUM—The production of the light metal, magnesium, is a chemical procedure. Its production, however, demonstrates the interrelated dependence of every industry. The operations that make it possible to extract magnesium from the waters of the sea are predicated upon basic operations that are guaranteed by the mechanical equipment made and designed especially for it. The task of winning magnesium from the sea is one that calls for the concentration of the metal from a solution in which it is present to the extent of 1.2 thousandths of a percent. Thus in a million pounds of sea water there are 1200 pounds of magnesium. Much of the operation rests solely upon the blending of two important skills—the skill of the mechanical engineer in making equipment that will work, and the skill of the chemist and chemical engineer in designing and visualizing the overall operation.

In the very beginning of the magnesium extraction process, there is ample proof that the skills and techniques of the mechanical engineer play an important part. Four pumps, each capable of delivering 70,000 gallons per minute, take in the water from the sea. Each pump, roughly, is doing 170 horsepower of work. The trash in the sea is screened out of the water before it is delivered to the plant—seemingly, a casual procedure, were it not that the successful screening of water calls for the use of special metals to prevent corrosion and short life of the screen. Not only does sea water present a hazard, but galvanic currents require special study and expert correction to prevent loss and shutdown time.

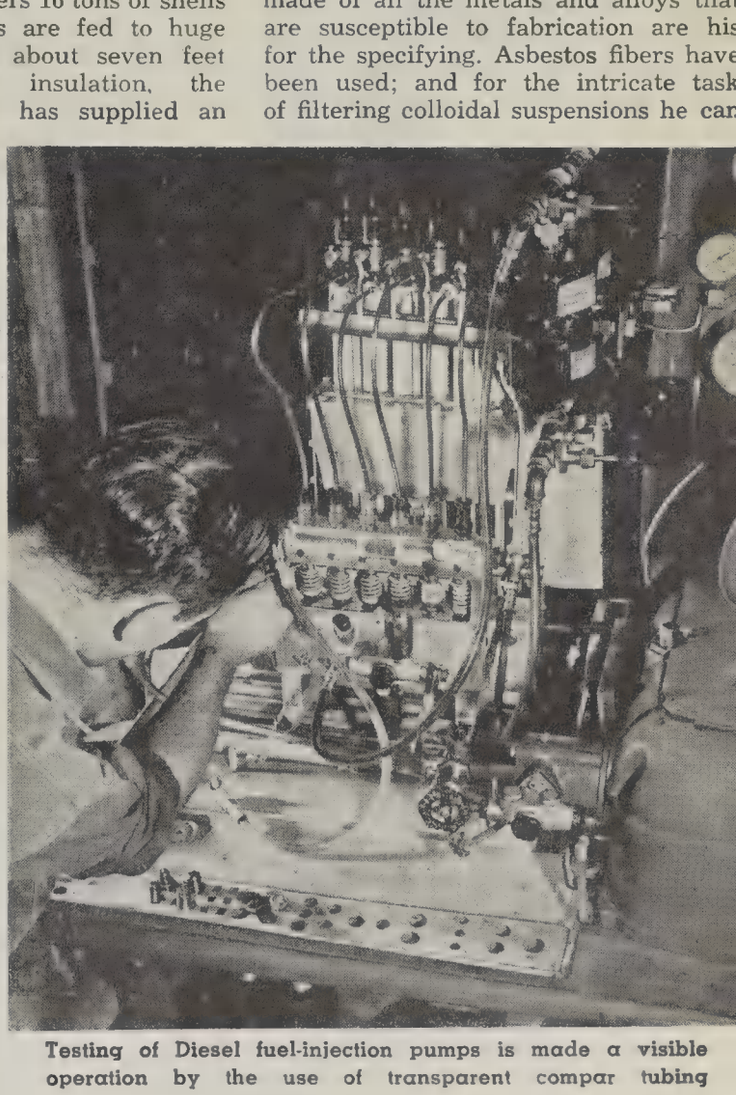
One of the important side processes in making magnesium is the production of lime from oyster shells. These shells are fed to kilns by a special belt arrangement that delivers 16 tons of shells per hour. The shells are fed to huge 3000-foot-long kilns about seven feet in diameter. For insulation, the mechanical engineer has supplied an improvement on the old fire brick which he first used to insulate steam boilers. A half foot of fire brick is used to seal off the tremendous temperature of 1300 degrees, Fahrenheit. The heat makes calcium oxide (lime) from the oyster shells, which are essentially calcium carbonate. Kilns of these sizes are capable of making about 150 tons of lime per day.

TANTALUM STEPS IN—The processing of chemicals today calls upon expert specialization in the mechanical field. Centrifugal pumps have been designed and made of special chemically developed alloys capable of handling acids of any concentration. Once the making of hydrochloric acid was an especially dangerous operation because of high corrosion rates. Complete installations of chemical quartz had to be made, but this was a procedure that was hampered by fragility and expense. Today tantalum, formerly a rare metal, is being fabricated into units that successfully handle hydrochloric acid with a minimum of corrosion. Heaters for acid solutions are constructed from this same metal, and industrial processes move more certainly and for longer periods because of the co-operation between the chemist and the engineer.

Process industries were once handicapped when it came to the filtration of solids from acid or alkaline solutions. Now the mechanical engineer has his choice of materials with which to equip any filter press that is used to filter the corrosive solutions of modern technology. He may use cloth made of glass, rubber, or plastic. Wire cloth made of all the metals and alloys that are susceptible to fabrication are his for the specifying. Asbestos fibers have been used; and for the intricate task of filtering colloidal suspensions he can



Portable mechanical mixers play a large part in the efficient operation of pilot plants and in small-batch work



Testing of Diesel fuel-injection pumps is made a visible operation by the use of transparent compar tubing

use rubber of minute cell structure and, perhaps, glass if the future development of this field continues at the same rapid pace that has characterized it in the past.

The engineering industries avidly adapt the inventions of the chemist and in turn the chemist is the faithful customer of the engineer. Thus, in building one of the new catalytic cracking plants, which is solely a chemical development based on the practical application of chemical principles, over 340,000 pounds of valves and fittings were purchased. In addition, well over 300,000 pounds of tubing for heat exchangers had to be used, while the pump manufacturers were some $56,000 richer because of the project.

Into the same plant went 89,000 feet of piping. Instruments for the control of the process cost $47,000 and electric motors to run the machinery cost $14,000. In any line-up such as that, it is a foregone conclusion that the industries are interdependent.

The synthetic rubber program of the United States is massive and impressive, but no less impressive are the feats of the mechanical engineers in making working equipment out of substitute materials. The boiler installations that



Non-corrosive glass tanks, designed for Westinghouse by Pittsburgh Plate Glass as a war-time substitute for metal and wood tanks, are found better in many ways than old types

produce steam for the rubber plants are intricate but at the same time compact units that represent a high point in efficiency.

At one of the butadiene plants there is a steam unit that can make 50 million pounds of high pressure steam a day. Without this steam not a pound of rubber could be produced. The engineering profession, its members working together, is the keynote of industrial achievement.

WORKING ON STUMPS—One of the most chemical of industries is the production of turpentines, rosins, and other pine derivatives from the stumps left behind in our Southern lands when the logger moves out. From the very inception it was realized that the industry depended upon proper chemical methods for its life. Yet it could not continue to function were it not for the development of mechanical aids. At one time, the stumps were pulled out by mule power or blasted out by dynamite. Today, special tractors with huge cranes efficiently extract the stump from the ground. It took years for this particular method to be perfected, but now after many trials this has been accomplished. The cranes that remove the stumps can travel easily over rough terrain. On the end of the crane boom is a large head, called the "nutcracker," which is lowered over the stump; internal teeth in the head of the nutcracker clasp the stump, and as the upward pulling strain of the crane becomes greater, the teeth sink deeper into the pine stump.

This particular industry, says the largest company in the business, was given a big impetus "by the development of a satisfactory 'hog' for the reduction of the stump wood to properly sized pieces for processing. The hog . . . devours irregularly shaped pieces of wood eight feet long and over a foot thick with no difficulty."

In the plant of this company, great dependence is placed on mechanical equipment. To eliminate metal pieces, a magnetic "eye" is placed over the belt that conveys the wood chips; when metal is detected, the belt is reversed automatically and the contents discharged to the waste pile.

Without the help of the other sciences and engineering techniques, the chemical industry could not function. Industry, more than ever before, is interdependent, and what one develops the other uses.

FLYING RUBBER

Gives Good Account of Itself in Bombers

RUBBER used in airplanes is not limited to tires. Each four-motored bomber, exclusive of tires, requires almost one ton of synthetic rubber. The huge B-29 uses more than that, for it is estimated that one of these giants requires almost two and a half tons of rubber in its construction.

Bullet-sealing gas tanks; rubber sponge in wing voids to sop up spilled gasoline; oil-resistant hose for the hydraulic, fuel, and oil lines; diaphragms; valves; and gaskets help to make up the huge quantities of rubber that go into the sky giants.

PENICILLIN ACTION

Requires that Drug be Administered by Injection

PENICILLIN does not destroy bacteria directly, according to the latest information on this subject, but prevents the fission or subdivision of the bacteria cell. Thus the magic drug, by preventing the rapid growth of harmful bacteria, allows the normal body action to carry off the attacking organisms. This is the job of the blood leucocytes, which apparently are not harmed by the penicillin.

Because the stomach generates acid, all penicillin must be administered either by intramuscular or intravenous injection; the salts of penicillin are destroyed by acid conditions.

PROTEINASE

Useful in Industry Obtained from Waste

ASPARAGUS butts, a waste product of the canning industry in certain areas, may find useful application if the plans of chemists from the United States Department of Agriculture bear fruit. Working in the Government's Western Regional Research Laboratories at Albany, California, three scientists found that juice pressed from these butts can be used as a culture medium to produce bacterial proteinase, an enzyme that digests proteins. Bacterial proteinase is used in the brewing industry for chill-proofing malted beverages, in the leather and textile industries, and in the recovery of silver from used photographic film.

It was also found that the juice could be used as a culture medium for other processes as a replacement for vegetable materials that are now scarce.

TANNIN

Can Now be Obtained From Hemlock Bark

CHESTNUT blight has seriously depleted the nation's source of tannin; from the chestnut tree could be obtained a rich and economical supply of this material. One of the substitutes that has been proposed is western hemlock tannin, and a method of making this tanning material from the bark of this tree has been discovered.

At pulping centers in the western United States there is a large and inexpensive source of bark, and through mechanical pressing and chemical leaching, it is thought that a commerical process can be started that will prove competitive with other sources of tannin.

COLORED SMOKES

Employ Mixtures of Dye and Fuel

COLORED signal smokes are being used extensively in this war as a way of signaling to distant observers. Most of the colors are produced by volatilizing organic dyes by burning a fuel and a dye together. Successful colored smokes are made by using dyes of the anthraquinone type, and the fuel mixture that gives the best service is probably potassium chlorate and a combustible material such as sulfur or sugar. For signaling, colored smokes are necessary in battle as there must be a distinction between the signal and the huge quantities of smoke given off by bursting shells and burning equipment. It is possible through the proper combinations to make smokes of the following colors—yellow, red, orange, violet, green, blue, and deep blue.

Heat Transfer

Some of the Fundamental Science Surrounding the Many Ways in which Heat Transfer is Involved in the Machinery of Modern Industry. Five Different Basic Mechanisms for Transferring Heat. Many Large Companies Maintain Basic Research on These Problems Because of their Importance

By G. W. PENNEY

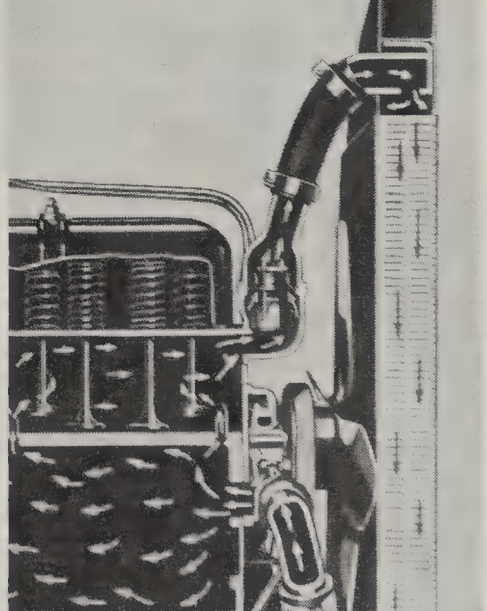
Research Laboratories, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

With the advent of the machine age, one of the major developments has been the provision of means for rapidly transferring heat. Our modern way of living would be almost out of the question were it not for these developments. Most examples of heat transfer are accomplished by one of the following means: conduction, radiation, convection, evaporation, and condensation.

CONDUCTION — Heat conduction is the transfer of heat within a substance when there is no relative motion of the various parts. Heat is a form of molecular energy which may be thought of as a vibration of the molecules. If one part of the substance is hotter than other parts, the increased molecular energy in the hotter portion is gradually communicated from molecule to molecule and we say that heat is conducted from the hotter part of the substance to cooler parts.

We can find materials having a wide range of thermal conductivity, but there is no substance which can be regarded as a non-conductor of heat to the same degree that we are able to provide electrical insulators. Among ordinary materials copper is our best conductor of heat. Low density materials, such as granulated cork, glass wool, eiderdown, and similar materials, are the poorest conductors. These poor conductors or thermal insulators have a thermal resistance approximately 10,000 times that of copper. Compared with this, a good electrical insulator has from a million-billion (10^{15}) to a million-billion-billion (10^{24}) times the electrical resistivity of copper. Such resistivity of electrical insulators is so great that, if we want to equip a handle for an electric switch, a piece of paper can to all practical purposes isolate the handle, so that in touching the handle we do not feel any shock. In the case of an ordinary cooking utensil we want to provide a handle which will stay cool even though the dish is hot. For this purpose we may use a handle of wood, plastics, or some other poor conductor, and so provide a handle which is usable, but we are unable to provide a handle which is a perfect thermal insulator.

In general, metals are the best conductors of heat. Those which conduct electricity best are also the best conductors of heat. The Wiedemann-Franz law states that at a given temperature the ratio of thermal conductivity to electrical conductivity is the same for all metals. Experimental values agree with this theory so closely as to indicate strongly that the mechanism which conducts heat in a metal is closely related to the mechanism giving electrical conductivity, although the exact nature of the relationship has not been completely explained.



Courtesy General Motors

The cooling system in your car is a homely example of heat exchange

Copper, which is one of our best electrical conductors, has a thermal conductivity over 100 times that of common dense non-conductors of electricity such as sandstone, granite, slate, or glass. Metals and alloys range in conductivity from silver and copper down to alloys having a thermal conductivity comparable to the dense non-conductors.

There is no known dense or non-porous material which is a good thermal insulator. However, by subdividing such a material, many small pores filled with air are provided, and air, when it is thus prevented from circulating, is a very poor conductor of heat. Hence all our common thermal insulators merely approach the thermal conductivity of air. You may ask, "Why use insulation if it has no lower thermal conductivity than the air which already surrounds things?" The reason is that air in any space of appreciable size will move about or circulate and so transfer heat by convection and the heat transferred by convection will be many times that transferred by its thermal conductivity.

If we must secure a heat conductivity lower than that of air, one expedient is to exhaust the air, as in the common vacuum or thermos bottle, but this is not practicable in large structures. Filling the pores of a substance with a gas having a lower thermal conductivity than air gives a moderate improvement. It is difficult, however, to seal the gas permanently, hence this is usually not a practical solution.

Another theoretical possibility uses low "accommodation coefficient" — a condition at the boundary between a solid and a gas which results in decreased thermal conduction. However, the effect at any one surface is small, so that to be useful there must be many such surfaces; that is, the gas spaces must be very small and the solid material must be broken up into very thin films or small fibers. Considerable progress is being made in this direction and a gradual improvement in such thermal insulation can be expected.

Even though in most cases we do not have an ideal thermal insulator we still can reach almost any desired low limit of heat loss merely by making the insulation thicker. We commonly call houses "insulated" if their construction includes insulating board only ¾ inch thick but, by filling the four-inch space between studding with insulation, very much lower heat losses

can be obtained. By increasing the thickness of insulation in refrigerators, houses, and so on, the loss through the insulation can be reduced to where it is small compared with the loss through air leakage, windows, metal parts, and the rest. Hence in most applications a better thermal insulator must also be inexpensive or it will not be used.

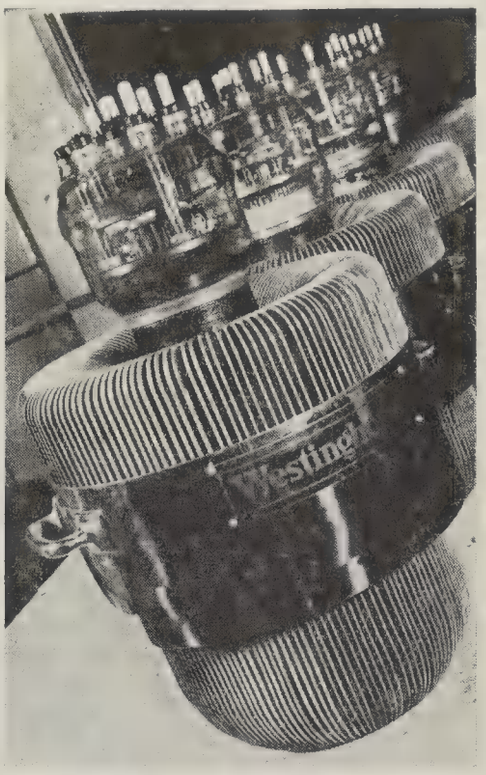
CONVECTION—Convection is often defined as the transfer of heat within a fluid by the relative motion of warmer and cooler parts of the fluid. Using this definition, the transfer of heat from a surface is said to consist of conduction through a relatively stagnant layer of gas followed by the transfer by convection over larger distances. This definition is not very useful because in most cases we cannot measure the separate effects. The quantity which can be measured and is therefore useful is the overall effect, or the transfer of heat from a surface to a moving fluid. For this reason engineers are coming to use the word "convection" to mean the transfer of heat between a solid and a fluid or between various portions of a fluid in which the heat is transferred by a combination of thermal conduction and motion of the fluid. This is the meaning given to "convection" in this discussion.

Almost all modern mechanical developments depend on convection to secure the high rates of heat transfer required for their proper operation. In heating a house the old method was merely to provide a stove or fireplace which heated the adjacent air, and the accompanying change in density caused the air to circulate. This has been called natural convection. However, this did not adequately equalize the temperature in various parts of a room. Now ventilating systems have provided forced convection by means of fans so that air is circulated rapidly throughout the house with only a small change in air temperature.

Many of the improvements in modern machines have been made possible by advances in the art of transferring heat by forced convection. In forced convection, heat is conducted from a surface to the adjacent fluid, and a fan or pump is used to move the fluid so that the heated fluid will be carried away and replaced by cooler fluid. By increasing the velocity, cooler fluid is brought closer to the surface. In this way the heat transfer rate can be increased almost indefinitely. However, the surface heat transfer rate increases only approximately as the ¾ power of the velocity, while the power required to circulate the fluid through a given duct system commonly increases as the cube of the velocity. From this relation it follows that, to double the rate of heat transfer, the power required to drive the fan or pump will increase 16 times. This gives an economical limit beyond which it is impractical to increase the rate of heat transfer by increasing the velocity of a fluid.

Particularly in the case of air cooling, finned surfaces have been used to increase the surface exposed to air and thus increase the heat dissipated from a given object. Many tricks are used to produce turbulent motion of the air to bring cool air over surfaces. Deflectors and guide vanes can be used to bring air to points which would otherwise be poorly cooled. The radial aircraft engine is one of the best examples of air cooling. In this case a large supply of high-velocity air is fortunately available. Such important advances have been made in air-cooled engines that some engineers predict that we will again be using them in automobiles and trucks.

In many pieces of apparatus, heat is generated in such small volume that it becomes impractical to cool the part



25,000-watt broadcasting tubes with cooling fins (heat exchange)

by air, and in this case we usually resort to water cooling—water is usually the most effective coolant available. For example, large radio transmitting tubes have a very high concentration of heat at the anode and on tubes of the highest powers water cooling is used. In one typical modern oscillator tube the losses amount to 20 kilowatts in a cylinder 3 inches in diameter by 6½ inches long. This amounts to 68,000 Btu per hour or enough to heat a typical six-room house in zero weather. To remove the heat from this small area without allowing the surface to exceed 100 degrees, Centigrade, water must be circulated over the surface at high velocity. However, water cooling requires piping and other complications, including the fact that the stream of water used for cooling may conduct electricity where it is not wanted. For these reasons, radio transmitting tubes are sometimes used at somewhat less than full rating in order to permit the use of air cooling. Air cooling is accomplished by the use of long copper fins spaced very close together, over which air is passed at a high velocity.

The modern x-ray tube is another example of a highly developed cooling system. In order that the x-rays may approximate a point source, high energy electrons must strike a small spot on the anode. This anode may be at a potential of 100,000 volts, and therefore, to secure electrical insulation, oil cooling must be used. Oil is ordinarily a poor coolant, compared with water, but by using pressures of 30 to 60 pounds and especially devised passages, a rate of cooling with oil is secured which would ordinarily be accomplished only by water cooling, at the same time providing adequate electrical insulation.

Central station boilers require enormous surfaces to transfer the heat from the burning gases to the water. To reduce the size of the boiler it has been found economical to use large fans to draw the gases of combustion through the boiler tubes and discharge these gases up the chimney. This contrasts with older schemes in which the chimney produced the draft.

Modern rotating electrical machinery is possible only because of highly developed cooling systems. In the electric locomotive space is very limited and fans therefore are used to draw the air over the motors and control apparatus. In most rotating machines many small ducts have been provided through which air is blown at high velocities. However, in locations such as steel mills, dust gradually fills these ducts and leads to overheating. Filters and air washers were used but in many cases were not adequate and therefore closed systems were developed.

In the closed system a fan is used to draw air through the machine and blow it over water cooling coils and back into the machine; assuming that the housing is tight, no dust can get into the ducts. Recently the development of the Precipitron has given a sufficiently high efficiency in air cleaning that many steel mills have eliminated the water cooling coils by taking in outdoor air and cleaning this air with the Precipitron before blowing it through the machine.

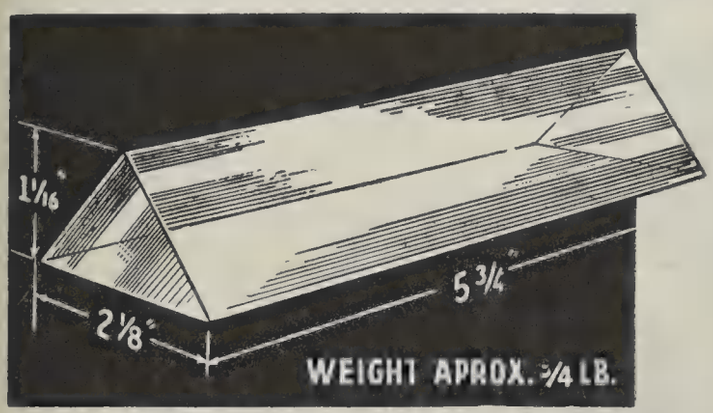
Turbo generators in our power plants have used enclosed machines with water cooling coils to cool the air, but here another limit was reached. In order to obtain efficient turbine operation, these machines must run at high speed and, to improve the cooling, air velocities were increased until the power required to move the cooling air was greater than that in the heat removed. This difficulty has been solved by the use of hydrogen cooling. Hydrogen has approximately the same thermal capacity per unit volume as air, but its density is less than 7 percent of that of air. The power required to force gas through common systems of ducts is nearly proportional to the density of the gas, and thus, by substituting hydrogen for air in a totally enclosed machine, the power required to circulate the gas can be reduced to approximately 7 percent. In addition to reducing the power required to drive the fan, the use of hydrogen eliminates oxidation of the insulation and increases the thermal conductivity of most insulation, since hydrogen has about seven times the thermal conductivity of air. Thus, by filling all small pores

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6021-S	18	49	Cemented	60¢
6022-S	25	95	Uncemented	50¢
6023-S	25	95	Cemented	75¢
6033-S	37	51	Uncemented	70¢
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in insulating materials with hydrogen, the conductivity of these insulating materials is increased.

It might be thought that the surface heat transfer rate would also be increased by seven times, but this is not the case since the heat transfer also depends on the viscosity of the gas. Because of this, the heat transfer secured by the use of hydrogen is, in many cases, only 25 percent greater than that obtained by air. A mixture of air and hydrogen is, of course, highly explosive, and so several years of research and development were required to perfect a means for making machines gas-tight and developing control devices to insure that an explosive mixture will never be present in the machine.

RADIATION—Heat is radiated by electromagnetic radiation. Its wavelength is frequently measured in microns. A micron is one millionth of a meter or 39.37 millionths of an inch. The eye is sensitive to wavelengths from about .38 to .76 microns. Radiation in this range is called light although it also transfers heat. All ordinary objects constantly emit and receive radiant energy. The amount of energy radiated from a given object is proportional to the fourth power of its absolute temperature. As the temperature of an object increases, the intensity of all wavelengths increases, but shorter wavelengths increase more than the longer wavelengths. Thus the average wavelength becomes shorter as the emitting object becomes hotter. At body temperature the maximum intensity of radiation occurs at about 10 microns. At 500 degrees, Centigrade, the maximum intensity is at 3.74 microns and the shorter wavelengths have increased so that an object commences to be visible in a dark room.

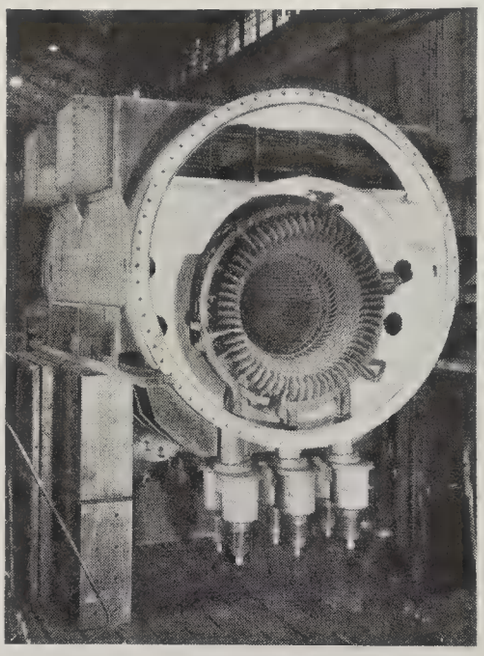
A typical 100-watt tungsten lamp filament operating at 2470 degrees, Centigrade, has the maximum intensity of radiation at 1.05 microns, which is outside the visible range. Thus the tungsten lamp is not the most efficient means of transforming energy into light. If the filament could be operated at a higher temperature, a larger fraction of the energy would be transformed into light. But higher temperatures result in too short life of the lamp.

The maximum intensity of sunlight is in the middle of the visible spectrum at about the maximum sensitivity of the eye. About one half of the radiant energy of the sun is in the visible range. Most of the remaining energy is in the infra-red, that is, wavelengths longer than the visible.

The transmission of infra-red radiation is similar to that of visible light, except that materials which transmit one wavelength do not necessarily transmit another wavelength and, likewise, materials which reflect one wavelength do not necessarily reflect another wavelength. Copper may be cited as an example. It is not a good reflector of light but is usually used as a reflector in radiant heaters because among common materials it is one of the best reflectors of wavelengths longer than one micron.

A material which is a good reflector for a given wavelength is necessarily a poor emitter of that same wavelength. That is, a material which would reflect a wavelength of two microns, if heated, would not be able to cool itself by giving off heat having a wavelength of two microns. The variation of reflectivity with wavelength provides a scientific explanation for the desirability of white clothing in the sunlight in hot weather. Ordinary white surfaces are good diffuse reflectors of visible light, usually reflecting over 75 percent of the solar energy. However, most white surfaces are poor reflectors—that is, good emitters—of wavelengths around 10 microns which predominate at body temperature.

A person, therefore, receives much less heat from the sun when he is wearing white clothing than when wearing black clothing. However, we must be able to dissipate or lose some heat and, since our normal body temperature is a relatively low one, white clothing is equally effective with black clothing for radiating these long wavelengths. If we desire to prevent the emission or absorption of longer wavelengths, bright, metallic surfaces are our only good materials.



Stator of a 25,000 kilowatt Westinghouse hydrogen-cooled turbine generator, its finned tube coolers visible near the top of the housing

Reasonably good thermal insulation can be provided by parallel spaced sheets of a bright metal such as aluminum. This tends to break up movement of the air, thus restricting heat transferred by convection. It also provides a series of reflecting surfaces which interfere with the radiation of heat.

Recent developments in glass provide interesting possibilities in the construction of houses. Ordinary window glass is transparent to wavelengths from about .3 to 4.7 microns and thus it absorbs less than 5 percent of the sun's energy. In summer when we want to air condition our homes, our windows admit light but also let in a large amount of additional heat radiated from the sun.

A glass has been developed which has reasonably good transmission in the visible range but absorbs most of the radiation longer than .8 micron. Thus with a given amount of light only about half of the heat is admitted that would be admitted if ordinary glass were used. However, to accomplish this requires a double window. The new glass, in absorbing the longer wavelengths, becomes appreciably warm; if it were used in the ordinary single glass window, a considerable portion of this heat of the sun would still find its way into the house from the warm glass. By providing a double window and using this heat-absorbing glass in the outer pane, and particularly if the air space between the two surfaces of glass is ventilated, very little of this heat that is absorbed by the glass finds its way into the house. In this way we can have a maximum of visibility with a minimum of heat from the sun transmitted into our rooms.

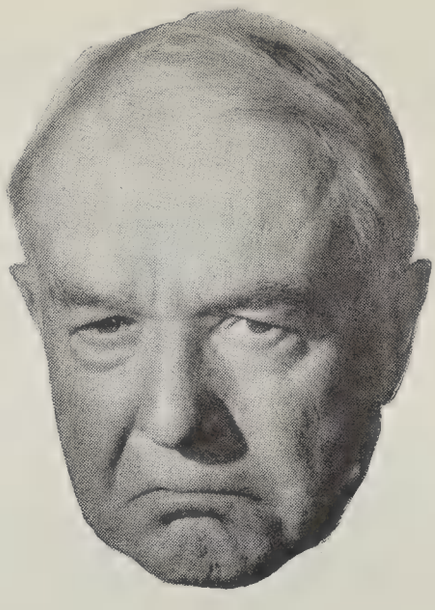
EVAPORATION AND CONDENSATION—We are all familiar with the fact that our bodies perspire in order that we may remain at a reasonable temperature even though the surrounding air is quite hot. But man made relatively little additional use of this phenomenon until the coming of the machine age. In the steam engine we use hot gases to evaporate water in a boiler, forming steam to operate the engine, and in more modern engines we also provide a condenser which permits the engine to abstract more power from the steam and also serves to return water to the boiler.

Refrigeration for preserving food and and air conditioning buildings depends on evaporation and condensation. For example, in air conditioning a building we use a liquid such as Freon which boils readily at relatively low temperatures. Boiling of the refrigerant removes heat from the walls of the vessel. Air may then be cooled by being blown over the Freon container. The vapor which has absorbed heat in cooling the air is then compressed to a higher pressure so that it will condense at a higher temperature. One of the major problems in modern air conditioning is the improvement of this heat transfer, first from the air to the boiling refrigerant, and then from the compressed refrigerant vapor to cooling water or air, in order to condense the refrigerant and return it as a liquid to the boiler. If this rate of heat transfer could be greatly improved, the difference in pressure between the boiler and condenser could be reduced. A reduction in the temperature difference between a boiling and condensing refrigerant would make possible the same amount of cooling with the expenditure of much less power, thus giving us more economical refrigeration.

In modern machinery for the factory and home the transfer of heat is highly important. A number of industries have large research and development programs aimed toward improvement of the cooling of apparatus. Many of the discoveries regarding the mechanism of heat transfer are making important forward strides in increasing the efficiency of machines and apparatus.



"I'll tell you GOOD TIMES ARE COMING!"



"I'll tell you BAD TIMES AHEAD!"

What's it to you?—PLENTY!

OKAY! Maybe the optimists are right. There'll be good times after the war.

OKAY! Maybe the pessimists are right. We'll have another depression.

What's it to you? PLENTY! It's largely in *your* hands as to which we'll have.

The one way to make it *good times* is to do your share to help keep prices down now!

That means *buying only what you really need.* It means *paying off your debts, saving your money.*

And here's where you're lucky. The same program that helps insure prosperity is also the best possible way to get yourself in shape to take another depression if one does come. So what? *You're right both ways*—if you save your money. *You lose both ways*—if you splurge right now.

Think it over, fella. Then get in there and fight. Read—and observe—the four rules to head off inflation. The war isn't over yet. And the war against *inflation* isn't over yet—by a long shot. Remember World War I? The cost of living rose twice as fast *after* the war as it did during the war itself.

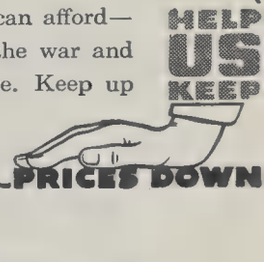
4 THINGS TO DO to keep prices down and help avoid another depression

1. Buy only what you really need.

2. When you buy, pay no more than ceiling prices. Pay your ration points in full.

3. Keep your *own* prices down. Don't take advantage of war conditions to ask more for your labor, your services, or the goods you sell.

4. *Save.* Buy and hold all the War Bonds you can afford—to help pay for the war and insure your future. Keep up your insurance.



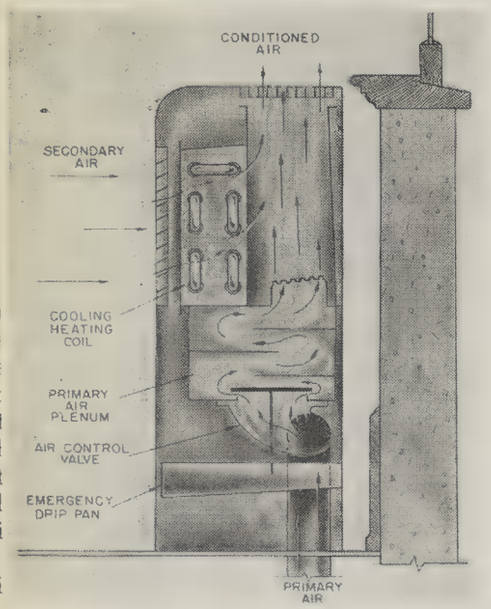
A United States War message prepared by the War Advertising Council, approved by the Office of War Information, and contributed by this magazine in cooperation with the Magazine Publishers of America.

Multi-Room Air Conditioning

Temperature and Humidity Control in Large Buildings with Many Small Rooms Has Been The Great Problem in Air Conditioning. Now a System Has Been Developed Based on High Pressure Flow of Conditioned Air Through Small Pipes, Eliminating the Space-Consuming Air Ducts of Earlier Methods

By JEROME CAMPBELL

SPECIALISTS in air conditioning have long been preoccupied with the difficult problem of cooling and heating the air, as the seasons require, in large buildings divided into many small rooms, and at the same time providing the desired degree of humidity. Now an air conditioning system has been developed for the specific purpose of controlling individually the "climate" inside each unit of multi-roomed structures. Said to be more economical and space-saving than any system before used, the new method has been successfully test-operated for some time. It



A cross-section of the Weathermaster room conditioning unit, showing the details of its design and functioning

is a product of the Carrier Corporation and has been named the Conduit Weathermaster System.

One superiority of the new system over older ways of conditioning the air in the many small rooms of hotels, hospitals, office buildings, and apartment houses lies in the fact that its pipes and conditioning units take up far less space. It also eliminates return air ducts completely and reduces the air supply ducts to conduits no larger than a plumber's waste pipe. In addition, the new system allows each room to be heated or cooled according to the desire of its occupant, although all the rooms receive their conditioned air from a central apparatus.

MAN-MADE WEATHER — Essentially a contemporary development, air conditioning has emerged only in the last 30 years as an important factor contributing to human comfort and the more economical output of manufactured articles. In industry it found its first useful applications. There it showed that more uniform, and hence better, products could be turned out if the temperature and moisture content of the air in factories were controlled.

Later, air conditioning was applied to theaters, department stores, and other buildings having large open areas. Americans soon learned to turn to the big movies houses as oases of coolness in the sweltering days of July and August.

Little progress was made, however, at that time in working out a practicable system of air conditioning for structures having a great number of small rooms. The reason was the unwieldiness of existing air conditioning systems. The installations employed huge air washers designed to handle vast quantities of air. They required giant fans and a system of space-consuming air supply and return ducts. In many cases, these huge ducts were large enough for a person easily to crawl through them.

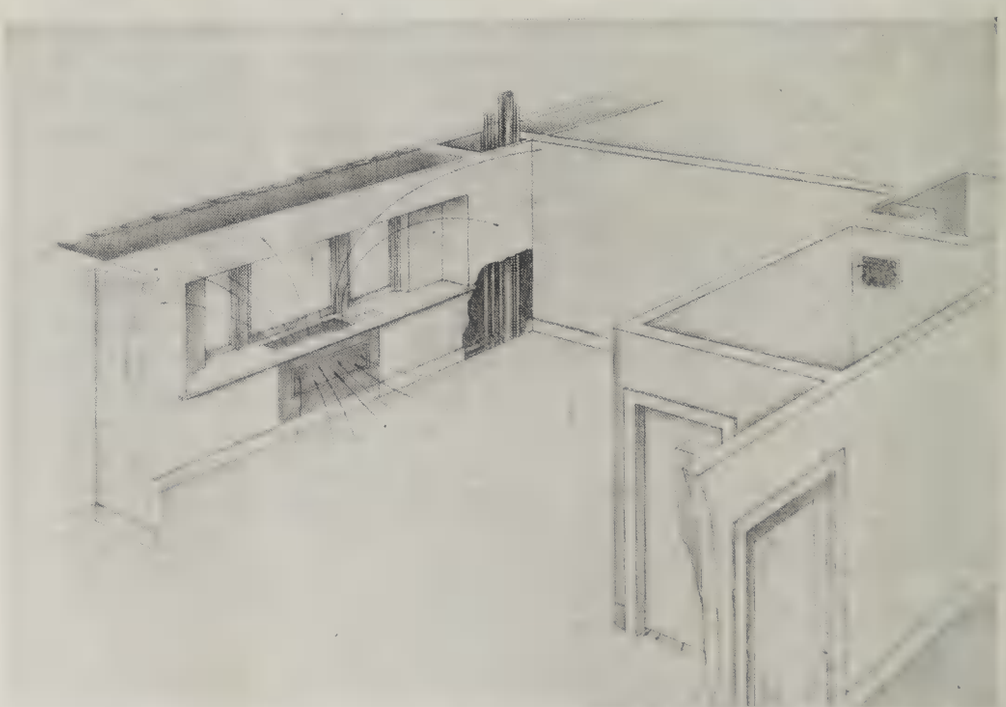
Such systems could not be used without great difficulty and expense in heating and cooling the air in buildings of the multi-cellular type. The small divisions in hotels, office buildings and apartment houses, hospitals and schools, could not economically be fitted with a complex network of heavy, ugly, space-consuming sheet metal ducts.

CONTROLLING INTERIOR CLIMATE—To obviate these weaknesses of the older systems of air conditioning, the Carrier Corporation conducted intensive research on this one phase. Now, after extended practical tests, the new system is ready for wide-scale use. Its essential characteristics are as follows:

1. It provides a central air conditioning apparatus about one third the size required by other systems.

2. The air, which is heated and humidified, or cooled and dehumidified, in the central apparatus, is exclusively outside or fresh air. It amounts to 20 percent, more or less, of the total air required for proper circulation in the conditioned rooms.

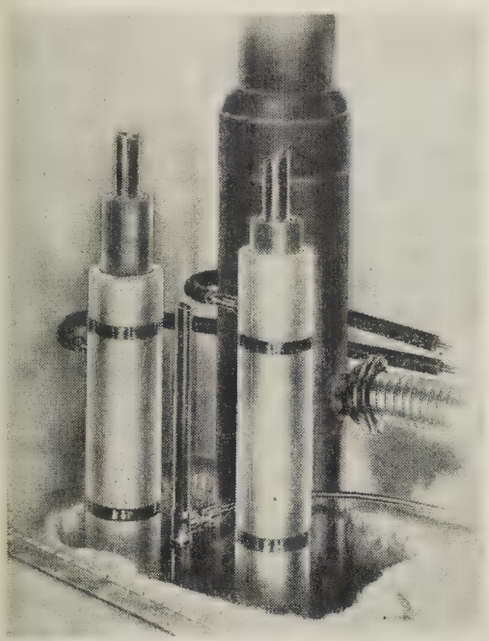
3. Small high-pressure fans discharge this conditioned air at static pressures



How the new Carrier system functions when installed in a hotel room

and velocities much higher than heretofore considered practical. Air velocities as high as 4000 feet per minute are usually employed or about 2½ times the duct velocity allowable in conventional systems.

4. Because of the small volume of conditioned fresh air and the high velocities employed, the new system is able to use air conduits instead of



A typical group of risers in the new system, showing air and water piping

ducts. The areas of these conduits are about one half of those employed in conventional duct systems. Replacing riser ducts, the conduits are, for the average installation, about 6½ inches in diameter for the largest size and are reduced in diameter for most part to about four inches.

5. Each room is equipped with a unit which replaces the conventional radiator, but which serves the room throughout the year—not merely in winter. The high velocity air enters this unit and is discharged through a series of small nozzles so designed that, despite air velocities of 4000 feet a minute, no noticeable noise results. The discharge of this primary air through the unit induces secondary air from the room to enter the unit in volume about four times as great as the conditioned fresh air. The induced air mixes with the fresh air and the mixture of 20 percent conditioned outside air and 80 percent induced room air leaves the unit at a relatively small velocity but in sufficient volume to provide gentle but adequate air movement throughout the room. The volume circulated is always constant. This is a great advantage.

6. Each room unit is provided with a supplementary conditioning device for heating or cooling the air as may be desired. In fact, the greater part of air treatment, whether heating or cooling, may take place in the room. This is controlled by a valve which automatically regulates the admission of heating or cooling fluids to the unit. Hence, an occupant may set the valve to get exactly the room temperature wanted. For example, one room may have its unit produce a temperature of 80 degrees while an adjacent room may have 70 degrees, to suit a particular occupant. The control is equally effective winter and summer and may be regulated so that it will give a desired low temperature at night, and a temperature of, say, 10 degrees higher during the day.

7. No recirculated air is employed at all. This completely eliminates return ducts. Thus, since only fresh air is sent from the central conditioner, there is no danger of contamination as may occur where the air from one room is returned to another. This is obviously of importance in hospital air conditioning.

Since the small fresh-air conduits and water lines may readily be housed in neat base-board enclosures and in small shafts such as are used for plumbing and other building services, the system may be installed without marring the interior effect of a room. The room units are pleasing in appearance, can harmonize with any decoration scheme, or may be concealed without jeopardizing their efficiency in any way.

From the housekeeping standpoint, the system assures freedom from odors, because no air is recirculated and no condensation takes place in the units. An effective filtering system substantially eliminates all dust.

EASILY INSTALLED—One of the outstanding practical features of the new Carrier system is the ease with which it can be installed in existing buildings. The cutting and patching necessary is relatively small. This is another ad-



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Through "hard coating" treatment of binocular lenses and prisms, Bausch & Lomb has achieved a 50% reduction of light loss due to surface reflections. Thus, the handicaps of poor light conditions are minimized—brighter, more clearly defined images are assured.

This important increase in light transmission is a definite advantage to our keen-eyed observers upon whose accuracy of observation so much depends. At dusk, in fog—under all adverse lighting conditions—this extra brilliance and extra definition may mean the difference between sight of an enemy plane or ship and a blank wall.

The optical system of every Bausch & Lomb Binocular—and many other B&L military instruments—receives this permanent coating treatment. To you, who plan on purchasing new binoculars after the war, this spectacular gain in light transmission represents another reason why Bausch & Lomb will be your choice.

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vantage of its elimination of return ducts and the use of air supply conduits with diameters of six inches or less. These features of the new system were purposely designed so as to be small enough to be installed in existing building pilasters.

Another attribute of the new system is the fact that its installation in new or already existing buildings may enable the owners to add considerable rental space. In buildings completely air-conditioned by the Weathermaster System, this gain has been estimated to be as much as one additional room for each ten rooms housed in a given space. In terms of a hotel or office building of 1000 rooms, this could mean 100 additional full-sized rooms in the same space.

All in all, the new air conditioning system holds out a great promise for more comfortable and healthful living in the future for millions of Americans. In the post-war years it may make inexpensive and efficient air conditioning as widespread in multi-room buildings as electric light and steam heat are today.

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ALUMINUM STRETCHING

Now Used to Harden and Form in One Operation

THE old-fashioned taffy pull now has an industrial counterpart at Ford's Willow Run bomber plant where millions of feet of aluminum material are being stretched and formed by unusual machines into structural parts for the B-24 bomber.

As you watch one of these stretching machines in operation, a 28-foot rib-like stringer actually grows more than a foot. The stretching of the aluminum is necessary to straighten, strain-harden, strengthen, and form parts that cannot be shaped efficiently by any other process.

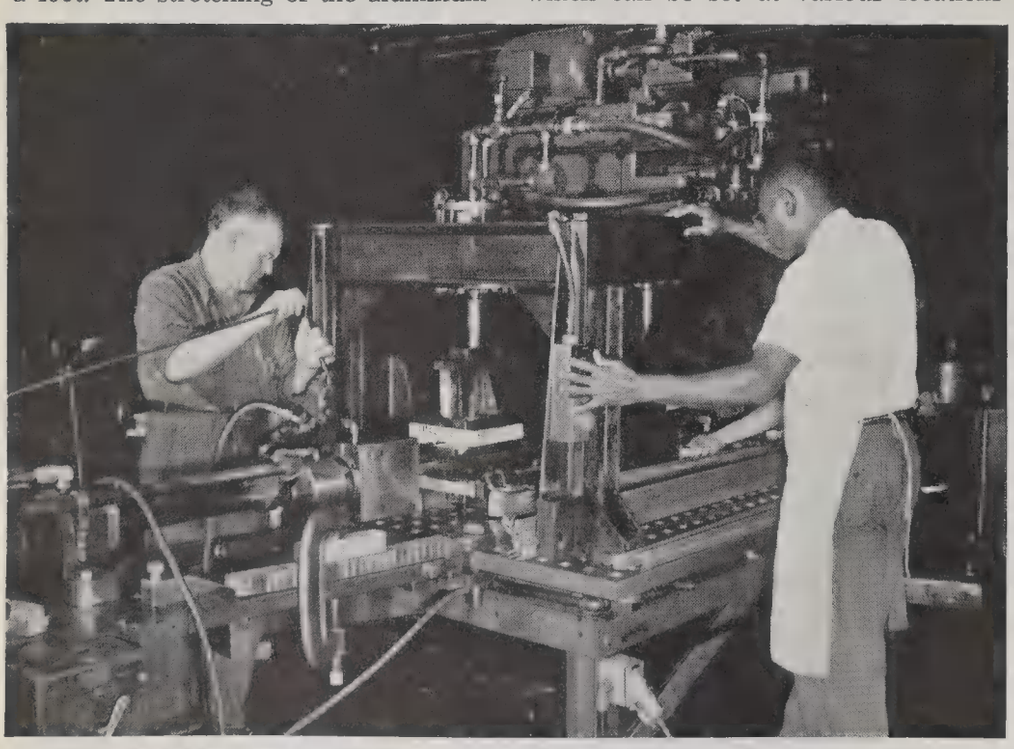
It has been found that the physical properties of aluminum are such that many bomber parts could not be formed efficiently by re-strike dies in presses, the "spring-back" of the material indicating that it must be drawn or form-stretched under pressure into the desired shape.

In order to provide means whereby parts could be formed adequately on a production basis, Ford tool design men combined the hardening and forming operations into one process called stretch-forming, using a stretcher die (similar to a press die) in a hydraulic stretching machine.

Stock is rolled in annealed condition or in heat-treated condition, preformed, and then sent to be heat-treated. After heat-treatment, this preformed channel, extrusion, or Y-section is gripped by specially fitted jaws, and stretched by hydraulic pressure over or around the stretcher die.

The explanation for the remarkable strengthening effects of this stretching process seems to be that each circular molecular body in the aluminum is drawn out into an egg-shaped elliptical particle, making the metal hard and strong. The stretch-forming process results in better parts and is easier to handle than re-striking. Furthermore, stretcher dies cost only 50 or 60 percent as much to build.

A 75-ton hydraulic pressure stretcher, believed to the most powerful stretching machine in the aircraft industry, is used at Willow Run to stretch the heavy-gage stringers used in the center wing section of the B-24 bomber. The stretching machine is made of three tubular tie rods about 35 feet long with cast iron supports at each end. The hydraulic unit is attached to the jaw at one end, and develops a pressure of 75 tons. The jaw at the other end is attached to a movable tail stop which can be set at various locations along the tie rods by clamping an interlocking washer into notches in the tie rods. The jaws are air operated. It is estimated that the machine will stretch 20,000 linear feet of the heavy stringer sections in nine hours.



An angle fairing, used to join wing and fuselage of a B-24 bomber, being stretched and formed as the stock is pulled horizontally through the stretcher die

COLOR DYNAMICS

Scientific Utilization of the Energy of Color

ACCORDING to recent studies on the subject of color dynamics, it is a simple matter to achieve three important industrial objectives: reduced absenteeism; improved efficiency, and higher worker morale.

Generally speaking, color dynamics is based on principles directly opposed to camouflage practices. To camouflage an object, color is used to hide and obscure; in color dynamics, as developed by the Pittsburgh Plate Glass Company, color is used to highlight, reveal, and emphasize.

There are three major parts to the industrial application of the principles of color dynamics—correct paint treatment of focal working areas, of walls and ceilings, and of floors and aisles. By applying the science of color dynamics to each of these, absenteeism is reduced, fewer injuries result, better morale and a higher level of quality are maintained.

STEAM GENERATION

Gains Economy Through Automatic Combustion Control

THE fundamental theories behind automatic combustion control for steam power generation in industry were recently put forth by M. J. Boho, of the Hagan Corporation.

According to Mr. Boho, "the modern boiler plant contains many different pieces of machinery, some necessary and others desirable in varying degrees. An engineer need not look too far back into the past to remember when a boiler plant consisted only of a feed pump, chimney, boiler, and a scoop shovel. These plants delivered the goods and, on this basis, it might be argued that all other equipment was unnecessary. Boiler plants are quite different today, however, and much of the equipment in general use, other than the bare essentials, now comes under the heading of necessities. Automatic combustion control is one of these.

"There probably is no engineering problem that has received more intensive study over the past several decades than that of reducing the cost of steam. The result of all this study has been the development of many different types of equipment. Some have achieved temporary popularity, only to be displaced by others as the art further developed. The fact that boiler combustion control has steadily gained in popularity is evidence of the fact that it has made a real contribution to economy of steam production.

"Where previously a combustion control system would have been classed as a luxury, today scarcely a single boiler of any consequence is installed

without a complete complement of combustion controls," continued Mr. Boho. To understand why, it is necessary only to consider the operating problems involved. In order to generate the maximum quantity of steam from a given quantity of fuel the ingredients entering into the combustion process must bear the proper relation to each other. In order that the steam produced have maximum value it must be supplied to turbine or process at uniform temperature and pressure. This requires that fuel and air be supplied the boiler furnace in proportion to the demand for steam.

"To obtain these results," Mr. Boho concluded, "a number of related variables must be maintained continuously at their proper relative values, and this becomes a difficult task if an operator has to take care of more than one steam generating unit. In order to change the steaming rate on a boiler, it is necessary to alter the draft at the boiler exit. This involves the adjustment of induced draft fan speed or damper, or a combination of both; also, to alter the forced draft which involves a change in damper position, fan speed, or both; and, finally, to alter the fuel feed so that it bears the proper relation to air flow."

BROADER EDUCATION

Not Hindered by War-Time Technology

THE American public is being unduly alarmed by liberal arts spokesmen who cry out against the possible ill-effects of war-time emphasis on technical training, declares Dr. Edwin Sharp Burdell, director of Cooper Union.

These alarmists warn that an undue burden of technical studies will exclude after the war the studies of man and human experience, says Dr. Burdell, who points out that studies sponsored by the Society for the Promotion of Engineering Education show that there exists in the nation's engineering schools "both a philosophy of engineering education and a plan for achieving practical objectives."

"It should be reassuring to the uninformed," Dr. Burdell explains, "to learn that engineering educators have set up two coördinate 'stems' of educational growth extending through the engineering curriculum—the scientific-technological and the humanistic-social stems—with the aim of developing informed, thinking citizens as well as efficient engineers. The very existence of these two 'stems' in the curriculum requires the closest possible integration in the academic development of the student."

There is current in learned circles today a specious notion that truth is to be sought and found only through and by the scientific method, commonly associated with the natural sciences, according to Dr. Burdell.

"This method of quantification and measurement when applied to inert or even living matter has yielded amazing results," he continues. "The scientist appears to have found the keys that unlock the secrets of nature. But that is not to say that he has necessarily found the keys that unlock the secrets of human nature or that he ever will achieve in the field of human values the sharp, clear-cut findings of mathematical physics. The storehouse of human knowledge and experience to be found in the great writings of history, literature, and philosophy will not be unlocked by chemical analysis, x-rays, or the calculus.

"The difficulty seems to have been that instruction and discussion in the realm of human and spiritual values has been largely confined to the level of higher education and to the so-called liberal arts field.

"There can be no greater crime against American education than the continuance of this isolation of the humanities from the great mass of our youth unless they enroll in a liberal arts college. The humanities and their 'scientific' counterparts, the social sciences, should be brought into the curricula of the high school, vocational school, junior college, technical institute, and engineering school.

"However, the mere exposure of students to the hundred great books is not sufficient. The purpose of introducing these subjects must be understood and endorsed by faculties and students. Some leaders in the field of engineering education have gone on record as saying that as much as one fifth to one fourth of the engineering curricula should be devoted to the socio-humanistic stem.

"If these clear-thinking, broad-minded executives, in close touch with the needs of industry, can see the value of this branch of learning in co-

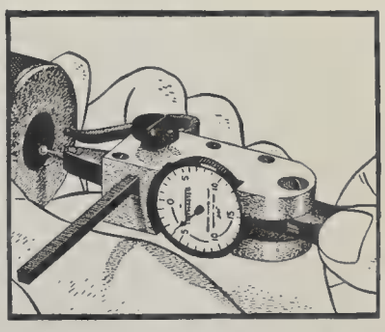


New Internal Gage Avoids Over Cutting... Saves Wasted Man Hours

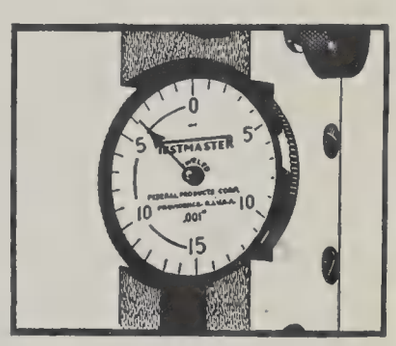
At last a gage that takes the guess work out of checking internal diameters either machine bored, or close ground and lapped. It is called the Keene Internal Gage and is the first accurate method for fast correct checking of internal splines and gears on both minimum and root diameters. The gage is ideal for machining and inspection work, and proves its value in increased production. It can be used with either a master, or micrometers.

This time saving development is constructed of aluminum, is six inches long and weighs only five ounces. Available in models designed to read in thousandths (.001) or in tenths (.0001).

When your gage has been checked the thousandths left to bore, the actual job of machining may become tedious. It is then when Wrigley's Spearmint Gum helps keep you alert and watchful. Chewing gum seems to assist you over the dull spots in the day's work. And Wrigley's Spearmint will aid you in your peacetime job by helping to keep you wide awake and efficient during that part of your work that may seem unimportant, but which actually means perfection to the completed product.



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ordination with science and technology, then other educators should be prepared to add it to other fields of vocational training. Thus there may be opened for the mechanic, tradesman, and housewife, in their youth, those long vistas of beauty and wisdom which are to be found in the humanistic-social studies."

SPECIALIZED HAULING

Accomplished by Unusual Types of Trucks

GIANT 30- to 50-ton super trucks have been developed by the automotive industry for specialized operations on the home front.

Weighing, when fully loaded, from two to three times as much as a General Sherman tank, these huge vehicles are taking an important part in the nation's war production program by transporting basic raw materials from open-pit metallic mines to refining plants, steamship docks, and railroad freight terminals. The trucks cover from three to 160 miles daily.

During 1943, for example, the trucks were credited with transporting an estimated 60 percent of all the nickel ore produced in the United States.

Among other unique war-time motor truck developments to date is a fleet of 73-foot tractor-trailer combinations designed especially to transport aircraft sub-assemblies between two war plants 1300 miles apart. Similarly, large truck-trailer units are being used to haul deck houses for Navy sub-chasers from fabricating plant to ship-building yard. Over-sized trailers which carry prefabricated house sections from factory to workers' housing areas in busy war centers, and mobile clothing stores which serve war-worker residents of rural communities are additional adaptions.

The ore-mining trucks are powered by Diesel engines and are built to carry loads which equal their weight. Many of them have been on continuous operation for more than 20,000 hours and have hauled millions of tons of raw ore.

In 1943, similar special motor trucks built for coal field operations were reported to have hauled more than 300 million tons of covering earth and coal from open-pit mines. Fuel-production goals for 1944 indicate that mine-operation trucks will establish a new record by transporting a total of over 400 million tons of coal.

Under actual operating conditions, a single 30-ton truck is able to transport 3000 tons of ore or coal on a short-haul basis every 24 hours, a volume equal to that carried in 60 average railroad gondola cars. At one coal mine, for example, records show that six of the largest type motor trucks consistently transport 9000 tons of coal in a seven-hour day over a three-mile route, a haul equal to that carried in 180 average rail car loads.—*Automotive War Production.*

DIAMETER MEASUREMENTS

Made by Imbedding Fine Wires in Plastics

A NEW method is now being used for measuring to a millionth of an inch the diameters of fine wires used in suspending galvanometer mirrors. The mirrors are attached to a small coil which rotates in response to minute currents flowing through a larger fixed coil around it. The suspension wire is twisted, and its diameter must be maintained with great accuracy if the instrument is to operate with the desired precision. Measurements made to a ten-thousandth of an inch with a good micrometer are not accurate enough.

Developed by E. D. Reilly, of the General Electric Works laboratory, the new method consists in molding, under heat and pressure, a plastics block with a series of V-shaped grooves in its upper surface. By limiting the amount of heat, the block is only partly "cured," otherwise the additional plastics which is later applied to it would not stick. Short pieces of the wires are placed in the grooves. Then the block is returned to the molding press, a very fine molding powder is poured over the wires, and a somewhat coarser powder is put on top. Again pressure and heat are applied, until the whole block is hard.

The fine powder works around the wires and grips them firmly, so that the block can be sawed across the wires without distorting them. If they were sawed or cut without being imbedded in the plastics they would be badly mashed.

The face of the block, which exposes the cross-section of the wire, is then carefully polished and examined under a microscope with a micrometer eyepiece. In this two threads are visible, and by moving them until they seem to touch diametrically opposite parts of the cross-section of the wire, the diameter is determined with a precision as great as a millionth of an inch.

ACID RESISTANCE

Offered by New Glass Made Without Sand

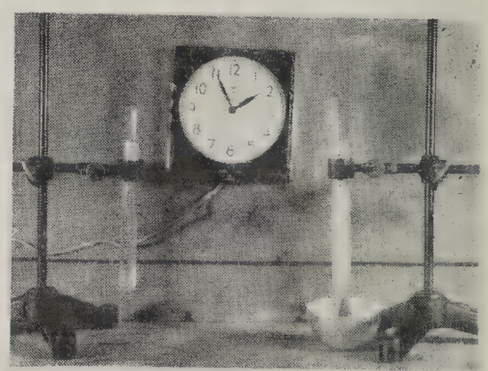
IN ADDITION to corroding most metals and causing dangerous burns, hydrofluoric acid disintegrates ordinary glass. Now a new kind of glass, which resists the corrosive effect of hydrofluoric acid, has been developed by the American Optical Company according to its research director, Dr. E. D. Tillyer.

The new glass, says Dr. Tillyer, was especially made to aid in the war effort, and is the first known glass to offer major resistance to the vicious attack of hydrofluoric acid. It was developed by Dr. Alexis G. Pincus, member of the concern's research laboratory.

The discovery, according to Dr. Pincus, is expected to simplify the handling of the important acid which now is extensively used in scientific experimentation, as well as in such industrial operations as pickling metals, etching glass, processing textiles, manufacturing fluorides and ceramics, and as a catalyst in oil refining and synthetic rubber manufacture.

"Previously," he explains, "the use of hydrofluoric acid presented difficulties because it could be shipped only in lead or wax containers while in the laboratory it had to be processed in platinum or gold retorts which prevented visual observance of chemical reactions."

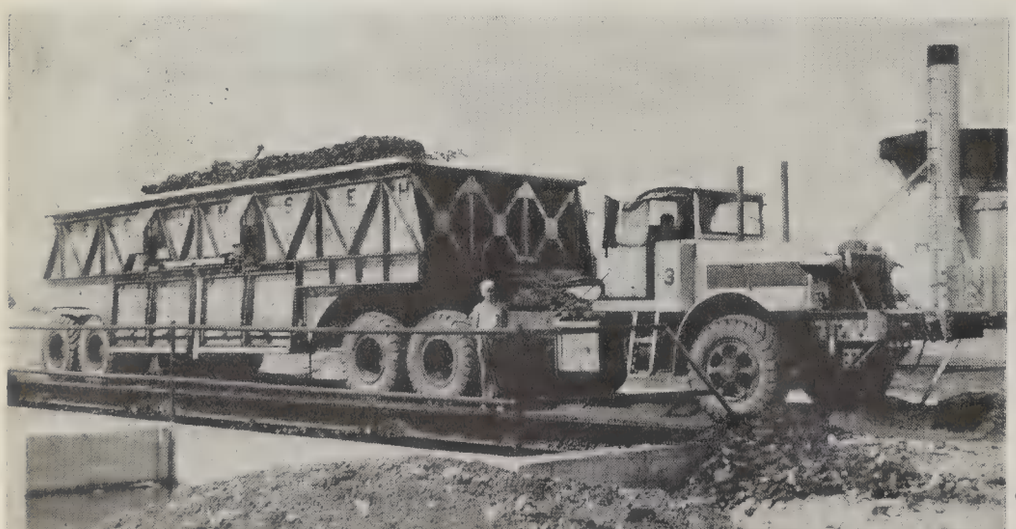
In a test made to demonstrate the acid-resisting property of the new glass, which resembles ordinary glass, a piece



In less than two hours, hydrofluoric acid has eaten through ordinary glass tube (right), but the tube of resistant glass (left) remains unaffected

was immersed in a bath of hydrofluoric acid for 500 hours. At the end of that time the glass was substantially transparent and to the naked eye showed no obvious attack.

"At the same time," Dr. Pincus says, "a piece of ordinary glass made of sand, lime, and soda was immersed in the acid and in a few hours was converted into a chalky mass. Even the tough and seemingly indestructible glass used in



One of the specialized trucks designed for hauling ore

the manufacture of laboratory and kitchen ware was rapidly attacked."

The new glass does not contain sand, unlike practically all commercial glass —a phenomenon akin to making steel without iron ore as the base. To obtain the hydrofluoric acid-resisting property, it was necessary to eliminate sand as a major ingredient because the acid instantaneously attacks sand, producing a disintegrating effect.

Major ingredient of the new glass is phosphorus pentoxide which by itself



One of the lenses in this worker's hood is of ordinary glass; the other is resistant to hydrofluoric acid. Note how acid has etched lens on left

instantly reacts with water with almost explosive violence. However, despite this remarkable affinity, the new glass is less soluble in water than ordinary glass, indicating the profound chemical change that takes place when the glass is made.

Since its melting and working properties are about the same as those of ordinary glass, it can be manufactured in a regular glass factory and be cast or drawn into sheets, or blown into bottles and other shapes. It can also be ground and polished, tempered, and subjected to other processes involved in glass technology without requiring special equipment or technique.

Potential uses of the new glass are in the fabrication of test tubes, beakers, bottles, evaporating dishes, and other containers; window panes for laboratories and factories where acids are employed; lenses for safety goggles and helmets; and glass gages to observe and check the action of acids in metal cylinders and reaction vessels.

TINNED WIRE

Now Produced by Electro-Tinning Process

HIGH-SPEED electro-tinning of copper wire, which requires only half as much scarce tin as do older methods, has been developed to a point where it is commercially practical.

Electrical wire ranging in sizes from those about as fine as a human hair on up to heavy gages can be coated in the new apparatus. Wire only five one-thousandths of an inch thick can be given its tin coat at the rate of 800 feet per minute, without breakage, and heavier strands may be put through at even higher speeds.

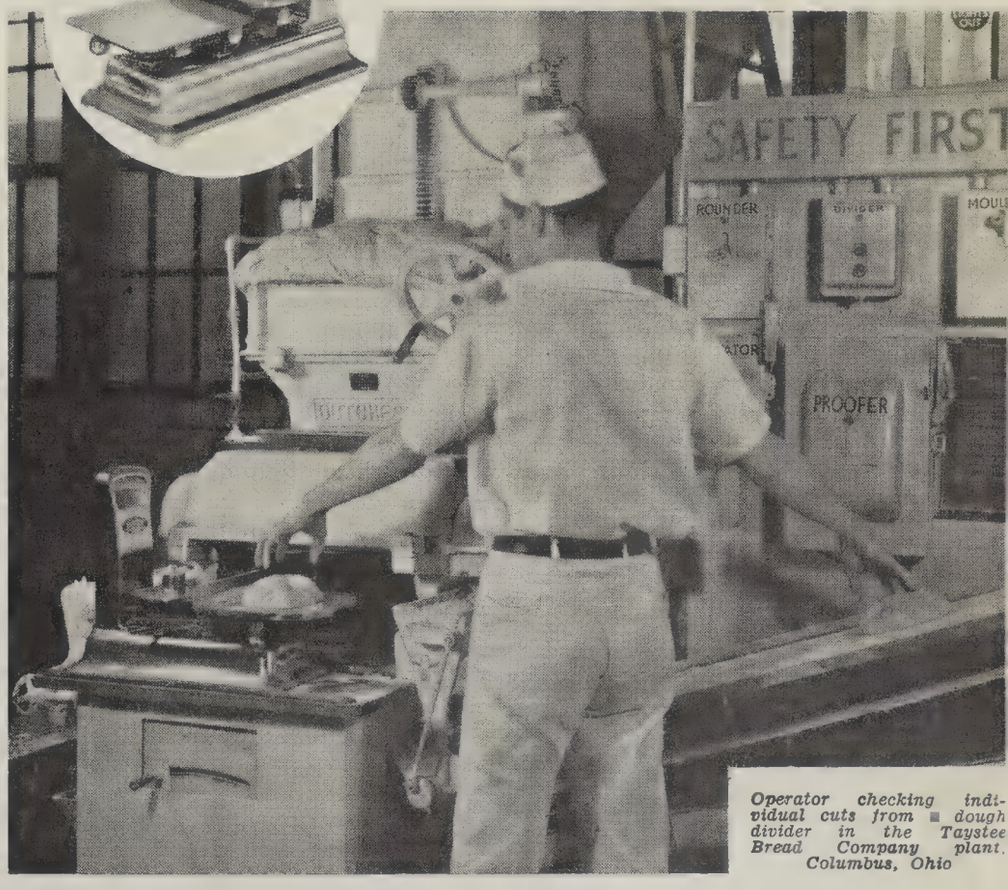
The wire-plating machine was designed and constructed by the National-Standard Company to utilize the Du Pont Halogen tin plating solution, which already has been extensively employed in the electroplating of strip steel for food cans. In the latter application the process has saved important tonnages of tin by replacing the hot-dip method.

Copper wire which is to be insulated with natural or synthetic rubber—and miles of it are used in the electrical industry—must be coated with tin for protection and other reasons before application of the insulation. Heretofore, when tin has been used for this purpose it has been applied in the molten form, in the so-called hot-dip process. This method picks up more tin than is necessary and the heat forms a copper-tin alloy on the wire, which increases its electrical resistivity and reduces its elongation properties.

The electrolytic process deposits the tin without producing an alloy and therefore does not affect the resistivity or elongation. Unlike the hot molten bath which must be periodically purified, at the expense of time and tin, the electrolytic bath does not become contaminated with copper.

The plating apparatus is ingeniously arranged so that there is a minimum of tension and drag on the wire. In fact, the wire zips in and out of as many as seven baths of cleaning and plating solutions without touching the rim of any of the tubs. It emerges from the

Dividing the Dough . . .



Operator checking individual cuts from ■ dough divider in the Taystee Bread Company plant. Columbus, Ohio

Dividing the dough. That is exactly what is being done above in a large bakery where mother's bread ■■■■ by sheer demand be turned out by machinery. Here is ■ divider that chops off pieces of dough at remarkable speed and with considerable accuracy for unbaked bread. But even dividers are not perfect and individual dough cuts ■■ carefully checked. When dough cuts ■■ heavy (over the required weight of the loaf before bake out) dividers are adjusted. The change may be but ¼ oz., ■■ important in ■■ loaf, but mighty unprofitable when 10,000 loaves ■■ involved. This is but another example of the ■■ of EXACT WEIGHT Scales, the leaders in pre-determined weighing in American Industry. Production engineers in any industry ■■ invited to write ■■ about their particular problems.

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baths with its smooth new coat of tin untouched by any metal or other solid material and therefore unscratched.

This "dainty dip" is achieved by keeping the baths "heaping full" and running over—re-circulation saves the fluid. They are so placed that the wire passes through the heaped-up part, the so-called inverted meniscus, just missing the rim of the vessels in each case. Instead of having a wiping mechanism to remove excess fluid between the baths, this is done by compressed air blasts. These arrangements not only subject the wires to a minimum of handling but facilitate stringing them up for the start of a plating run. They are simply laid over the top of the baths, and attached to let-off and take-up spools at the two ends of the apparatus.

AMMONIA

Important in War, Faces Increased Post-War Demands

HUGE post-war expansion in the consumption of ammonia is predicted in *Chemical and Engineering News*, a publication of the American Chemical Society, in a survey of chemical markets.

"Quick-freezing of foods and refrigeration are certain to require more ammonia than before the war," it is pointed out. "In frozen foods alone, production has grown tremendously—from 169 million pounds in 1938 to more than 960 million pounds in 1943—and food authorities believe it was boosted an additional 25 to 30 percent in 1944.

"Refrigeration commonly means the manufacture of ice and the cooling of cold storage plants, but ammonia also provides refrigeration for some important industrial processes such as petroleum refining, production of certain synthetic elastomers, and the nitriding of steel. Under the necessity of providing enormous war production, figured in terms of the finished materials, we have lost sight of these and other essential jobs performed for industry by ammonia.

"It is an irreplaceable chemical in the manufacture of other industrial chemicals, notably sulfuric acid, alcohol, soda ash, caustic soda, and it is the 'controlled atmosphere' for annealing electronic tubes, heating coils, electric heaters, and electric irons.

"Anhydrous ammonia has become so dominant in the fertilizer picture that we face a nitrogen shortage in 1945 because the Government is diverting ammonia and nitric acid to ordnance production, making crops dependent chiefly upon Chilean nitrate of soda, sulfate of ammonia from the coke-oven, and whatever natural organic materials may be available.

"When military needs have been met, ammonia undoubtedly will be freed again for agricultural nitrogen in the form of synthetic nitrate of soda, nitrogen solutions, and ammonium nitrate.

"If the wartime Federal ammonia plants can be taken out of farm politics and the issue of 'cheap fertilizers' left to the fertilizer industry, it is very likely that the post-war era will witness the development of new, highly efficient nitrogen fertilizer materials based on ammonia and urea. Nitrogen solutions have by no means reached a stage of full development. At least one large ammonia manufacturer is planning new developments along this line."

X-RAY TIMER

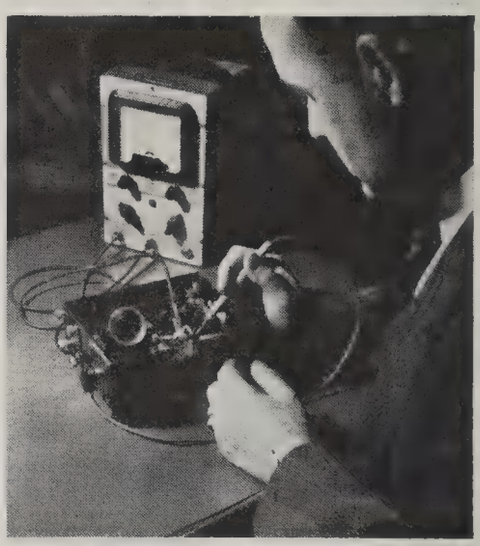
Speeds Examinations in Tuberculosis Checks

AN ELECTRIC eye "exposure meter" which enables a single crew of x-ray technicians to examine the chests of a thousand people a day for signs of tuberculosis—twice the number previously possible—is called the "phototimer." It is already in use in tuberculosis survey clinics, measuring the precise amount of x-radiation passing through a human chest, and shutting off the x-ray tube when a sufficient quantity has passed through to make a film exposure of the proper density and contrast.

"Miniature photofluorography—taking small-film photographs of full-scale images created on a fluoroscopic screen by the action of x-rays—is the only practical and economically-possible way to conduct the mass chest surveys necessary to detect the presence and prevalence of tuberculosis in the whole population," says A. P. Craig, manager of the X-Ray Division of Westinghouse.

"Its use makes possible the examination of sixty persons for the same film cost as a single examination using direct exposure of film by action of the x-rays," Mr. Craig adds. Such a survey is a fast "screening" process which spots unsuspected tuberculosis cases, and brings them to light so that further and detailed diagnosis and treatment is possible.

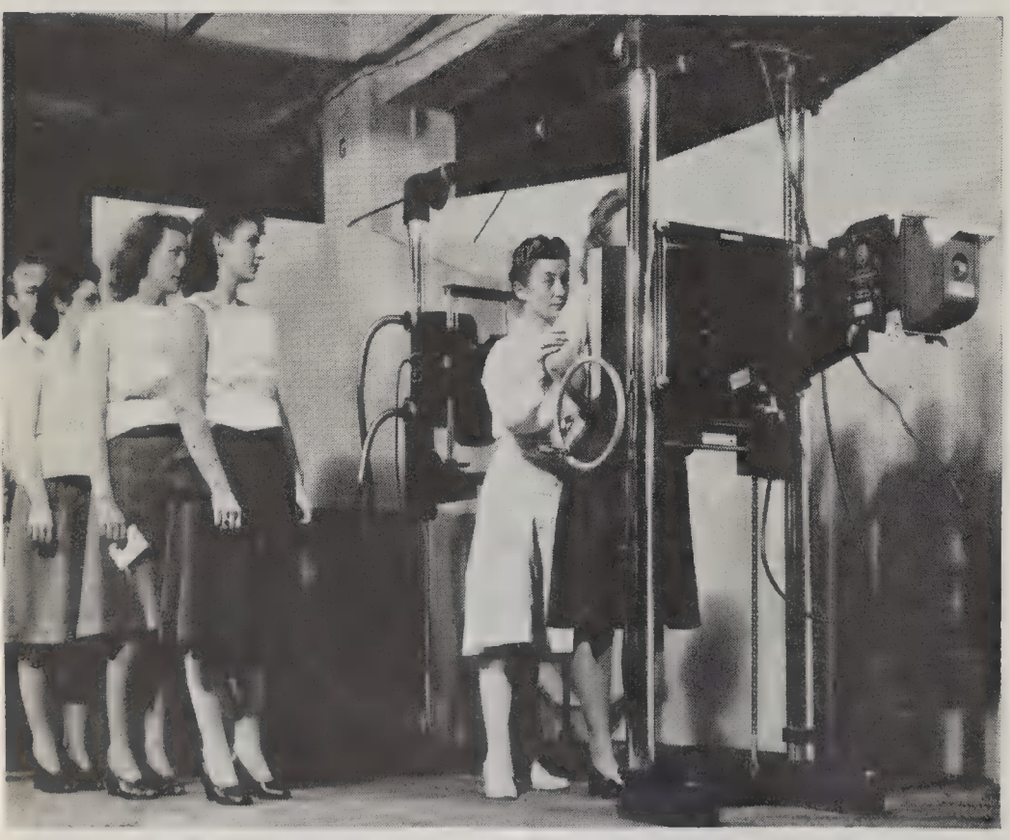
Until now, a major difficulty barring full utilization of the diagnostic capabilities of x-rays has been the lack of automatic exposure controls. This meant that every person brought before the x-ray camera for examination had to be individually measured by the technician handling the machine, and then a whole series of adjustments were necessary before his "picture" could be taken, to insure the uniform film negatives on which reliable examination results depend. The use of the new Westinghouse phototimer automatically assures a correct x-ray exposure, enabling the operating technician not only to x-ray twice as many persons a day as he formerly could, but to achieve better and more useful results as well.



Photocell in the x-ray timer measures light on fluorescent screen and controls length of exposure

The timer consists essentially of a photoelectric cell to "see" the light emanating from the fluorescent screen, a capacitor to store the electric current which flows in the tube as a result of this light, and an electronic "trigger tube" to shut off the x-ray tube when sufficient x-rays have penetrated.

The phototube "looks" at the screen simultaneously with the miniature camera mounted in the equipment; but, being mounted below the plane of light



New x-ray timer permits making 1000 examinations a day

beams entering the camera lens, it doesn't interfere with the action of the camera. It "sees" the same light, however, and thus can control the source of the light in a manner that will also control the exposure of the film.

CROWN GALL

Controlled by New Chemical Combinations

CHEMICAL research has found a new and effective way to control crown-gall, those rough, woody disease growths that weaken and often kill almond, walnut, peach, plum, apricot, and other trees and vines.

Pure synthetic methanol, the same chemical compound used as the base for anti-freeze for motors, is an important ingredient in two new chemical solutions now recommended for this purpose. These solutions are being applied with considerable success to "doctor" these harmful knotty growths which are caused by micro-organisms so tiny that it takes 25,000 of them, end to end, to reach only one inch.

The current issue of the Du Pont *Agricultural News Letter* reports that the latest recommendation, made by Dr. P. A. Ark, of the California Agricultural Experiment Station at Berkeley, following several years of testing under actual orchard conditions in his state, simply calls for exposing the gall, cleaning with a brush, and painting the entire surface with one of two mixtures. The first contains one part sodium dinitrocresol and four parts of methanol; the second, 100 parts by volume of methanol, 15 parts glacial acetic acid, and 12 parts by weight of crystal iodine.

Dr. Ark urges growers to experiment with the materials on a small scale and to seek the advice of agricultural authorities before undertaking large-scale operations.

TURBINE LOCOMOTIVE

Designed for High-Speed Passenger and Freight Service

A FUNDAMENTALLY new type of coal-burning steam locomotive, powered by a steam turbine in place of the cylinders, pistons, and driving rods of the conventional design, has been completed for the Pennsylvania Railroad. It is the first direct-drive steam-turbine locomotive ever built in the United States, and is now undergoing tests to determine the adaptability of this type of engine to long-distance high-speed passenger and freight service.

In the new locomotive, the turbine shaft is rotated by the pressure of jets of steam against the vanes of the turbine wheel. A continuous flow of power is thus transmitted to the driving wheels through speed-reducing gears. A product of continuous research and development, the engine was designed and constructed by the Baldwin Locomotive Works and the Westinghouse Electric and Manufacturing Company, in collaboration with the Pennsylvania Railroad.

The purpose of developing the new steam turbine locomotive is to eliminate the reciprocating parts of the conventional steam locomotive; to provide a uniform flow of power to the driving wheels; and to obtain the economies inherent in a turbine. The turbine is designed to develop 6900 shaft horsepower, and provides power at the tender coupler sufficient to pull a full-length passenger train at 100 miles an hour and high-class freight trains at high speeds.

The new engine is one of the simplest to operate that has ever been constructed. Both forward and reverse movements, at all speeds, are controlled by a single lever, actuating specially designed pneumatic control apparatus. Automatically functioning devices make incorrect handling of the mechanism impossible.

Smaller than a living-room easy chair, and accounting for less than 1 percent of the locomotive's total weight, the main or forward drive turbine is mounted at the right-hand side of the locomotive. It is approximately 45 inches in diameter. A smaller turbine, designed to move the locomotive backward at speeds up to 22 miles an hour, is mounted on the left side, and is brought into operation by engaging a clutch.

There are more than 1000 chromium steel vanes in the forward turbine, some of which are less than one inch long. Steam travels through the entire battery of turbine blades, expending all but 15 pounds of its energy. These produce a non-pulsating draft through the firebox and boiler. The boiler is of the conventional type, car-

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rying 310 pounds of steam pressure and fired by a mechanical stoker.

The heat-treated alloy-steel reducing gears, into which the turbine shaft feeds its power, operate continuously in an oil bath and mesh with so little friction that 97 percent of the turbine's power reaches the driving wheels. Power is applied directly to two center pairs of driving wheels and is also transmitted to two additional pairs of drivers by connecting rods. The engine is equipped with roller bearings throughout.

BETTER PAPER

Obtained Through Use of Synthetic Salt Cake

It has been discovered that synthetic salt cake used in the kraft pulping process does not need to be treated in the smelting furnace, according to Vernon Woodside of the Mathieson Alkali Works. Instead, it may be added directly to the green liquor in the dissolving tank.

The method of addition may vary as required by the plant system. The synthetic salt cake may be fed continuously into the green liquor, at a predetermined rate or, where a batch system is used, a measured quantity of salt cake per batch may be added to the dissolver tank.

The most important advantages claimed for the new process are greater control and flexibility of operations, potential chemical and fuel savings, and better average pulp quality.

STEAM ON RAILS

Is Advancing With the Times

The steam locomotive, streamlined and perfected to meet post-war requirements, will hold its own, despite development of other power sources, in the opinion of Ralph P. Johnson, chief engineer of The Baldwin Locomotive Works.

"Those who point with scorn to steam locomotives as being 'obsolete' and 'backward' and believe the iron horse will give way entirely to other forms of motive power, need only to observe the tremendous advances in steam power since Pearl Harbor to be convinced of the brilliant future for steam locomotives," Mr. Johnson points out.

"One highly advanced type of steam locomotive which has definitely proved itself in regular service is the Baldwin-designed four-cylinder type as exemplified by the Pennsylvania Railroad's streamlined 'T-1' class, two of which have been in continuous passenger service between Chicago and Harrisburg for two years," says Mr. Johnson. "This locomotive is capable of 100-mile-an-hour speed with a load of 880 tons, thereby avoiding the use of two engines on heavy passenger trains.

"The Diesel locomotive seems at the moment to be tied up to electric propulsion and this means that designing ingenuity will be confined to the Diesel engine itself. The Diesel will acquire an added appeal if future engines can be designed to burn lower grades of oil. Work is being done along these lines and post-war Diesel design will not be static," he concludes.

SILICONE RUBBER

Retains Properties at High And Low Temperatures

Retaining its elastic properties at temperatures as low as 60 degrees below zero, Fahrenheit, or as high as 575 degrees, silicone rubber has been developed in the General Electric Research Laboratory for many important war uses. One is in aircraft turbosuperchargers, another is in searchlights for the Navy.

For a number of years chemists have been studying the curious chemical compounds known as "silicones," of which an important constituent is the element silicon, present in such common things as sand and glass. Chemically, silicon is a close relative of carbon, upon which the vast family of organic compounds is based. Both elements can form long, chain-like molecules called polymers.

Organic polymers, such as rubber (either natural or synthetic) have as a backbone a string of carbon atoms which are joined directly to each other by primary valence forces. Silicone rubber is also a polymer. Its backbone consists of a series of units, each consisting of a silicon and an oxygen atom linked together. On the side, attached to the atoms of silicon, are groups of hydrogen and carbon, called hydrocarbons. In these silicone polymers, where the carbon atoms in the backbone are replaced by the silicon-oxygen linkages, the thermal stability is greatly improved in most cases.



How gaskets of the new silicone rubber, developed by General Electric research laboratory, are applied to the casing of a turbosupercharger

Developed entirely apart from the vast governmental synthetic rubber program, silicone rubber is now being manufactured in a pilot plant in the General Electric Company's Resin and Insulation Materials division. While government synthetic rubber is being made by tons, present silcone rubber output is measured in pounds, all of it going into high-priority war jobs.

One of the most important of these is a gasket for the turbo-superchargers in B-29 bombers. Gases from the exhaust, at a temperature well above a thousand degrees, are used to drive the turbine, which is thus subjected to high temperatures even though the air outside may be very cold when the plane is flying through the sub-stratosphere.

The compressor casing of the turbosupercharger is stamped from sheet steel and a gasket is needed to seal the cover plate over an opening about a foot in diameter. Natural rubber will not continue to provide the required resiliency over the temperature range encountered in this application. One synthetic rubber was tried but became hard and brittle after a hundred hours of operation. In contrast, a gasket of silicone rubber, even after operating continuously for 150 hours, is still soft and can be used over again satisfactorily. This is due to its lack of "compression set" at high temperatures. Silicone rubber can be compressed between metal plates to two thirds its original thickness, held that way for several hours at 300 degrees and, when



One of the "T-1" class of Baldwin locomotives built for the Pennsylvania Railroad

released, it returns to 90 percent of its former dimensions.

The raw materials from which silicone rubber is made are easily available, and it can be prepared in a wide variety of physical properties. Some types are rather soft, while others are hard. In its present state of development it is not suitable for tires and other uses where high tensile strength is required.

A by-product of the research in silicone rubber is a curious material referred to as "bouncing putty." It looks and feels like putty and can be pulled and kneaded in the same way. Yet when rolled into a ball and dropped on a hard surface it bounces like rubber. A putty ball would just flatten out without bouncing at all.

Scientifically, bouncing putty exhibits paradoxical properties, for it is both elastic and plastic. Which of these properties it exhibits depends upon the rate at which stress is applied. When rolled into a ball or pulled like taffy the deforming forces are applied slowly. Then it is plastic, the material flowing from one part of the mass to another. But when the ball is dropped and it hits the floor, the stress comes suddenly and then it behaves as an elastic material. Though this combination of properties is shown to a slight degree by other materials, silicone putty is the first in which it is so marked and thus it offers the opportunity for useful applications of these unusual properties.

BOILER WATER

Important to Shipping And Industry Alike

FRESH light on how chemical water control is keeping the ships of America's merchant fleet out of trouble was shed recently by a paper read before the Society of Naval Architects and Marine Engineers by Dr. A. C. Purdy, of Bull and Roberts.

Dr. Purdy, a consulting chemical engineer, presented his paper under the technical title, "Water Conditioning and Related Problems of Marine Boiler Operations." It was a sequel to a previous paper read by the water expert before the same body in 1933 and summarized new knowledge gained in the intervening years through research by Hall Laboratories and Bull and Roberts on the prevention of scale and corrosion in steam boilers.

Behind his seemingly prosaic discussion was as dramatic a story as any that have emerged from the war theaters. For in nearly three years of war, with America's merchant vessels fully engaged in cargo carrying all over the world, seldom has a ship using proved methods of chemical boiler-water control been laid up for even a day because of burned-out tubes or corroded boilers.

More than 1200 of the present fleet of merchant ships, Dr. Purdy says, use modern chemical control of their boiler water, and of the high-pressure boilers the figure is 80 percent.

The fact that these ships have not been compelled to wallow idly in the Indian Ocean, the Pacific, or the Atlantic at the mercy of submarines while their boilers were re-tubed or the old tubes turbined, Dr. Purdy says, has saved many a cargo from the enemy and given continued help to the Allied supply lines extending to all quarters of the world.

In his paper Dr. Purdy stressed the fact that post-war design of ships almost certainly will take into account higher steam temperatures, pressures, and ratings; that this will require closer chemical control to keep the boilers on the line; and that much that has been learned in solving the same problems for industrial power plants will be of value to the marine field.

Suggesting a new approach to water conditioning at higher operating pressures, he said that the solution "appears to lie in a closer study of what actually happens as the dilute over-all boiler water traverses those surfaces where steam is generated." Dr. Purdy added:

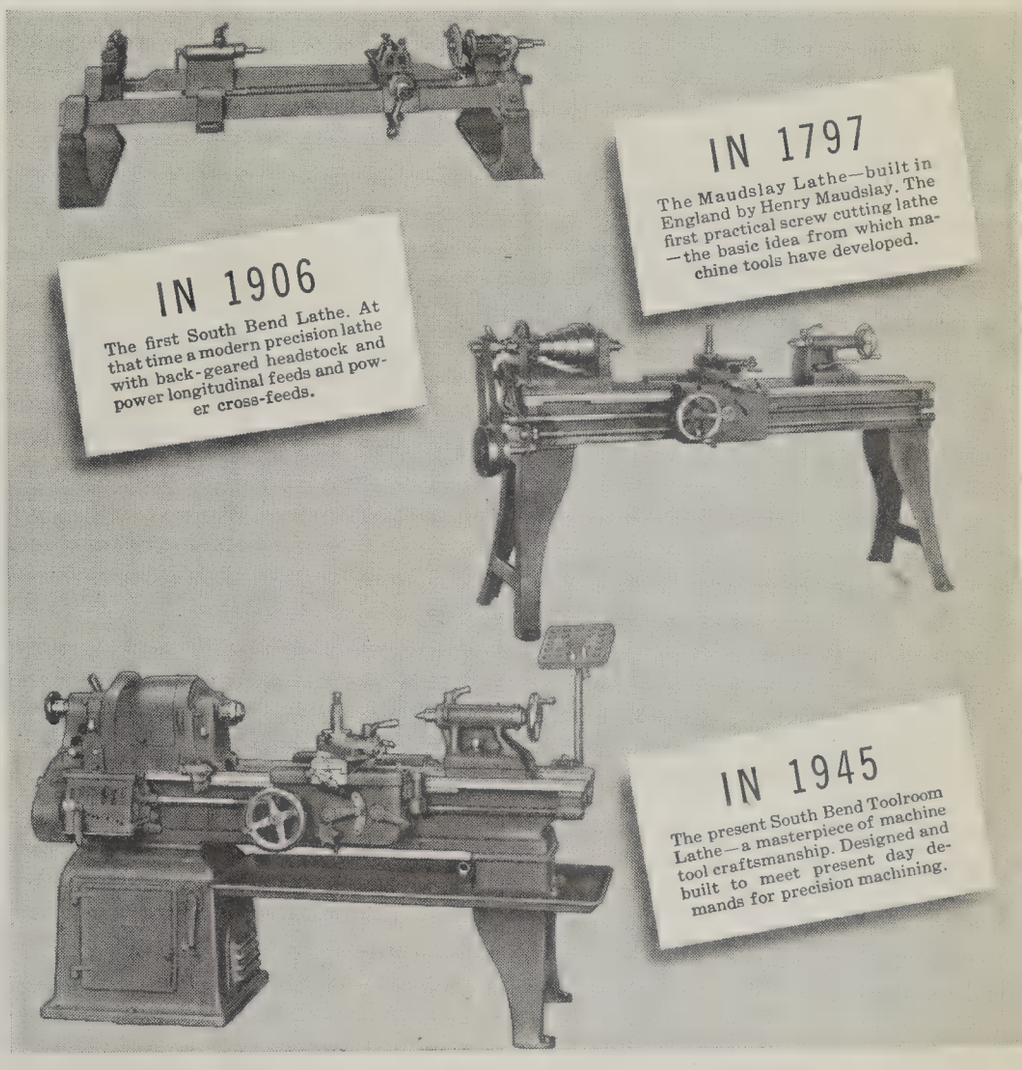
"Here the water must absorb the heat from the boiler tubes which receive it by radiation and convection from temperatures of 2000 to 2500 degrees, Fahrenheit, and must pass it on with sufficient rapidity so that the external surface temperatures will not exceed 800 to 900 degrees, Fahrenheit."

In conclusion, Dr. Purdy pointed out that the chemistry of boiler water is a constantly developing science in which many able research men are cooperating with boiler designers and operators to give the latter the greatest possible latitude in design. These developments should be followed with interest by naval architects and marine engineers.

POST-WAR CONSTRUCTION

Held to be Key to Vast Employment Problem

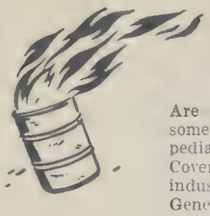
IN THE first three to five post-war years the United States will experience the greatest volume of industrial building and greatest employment of construction workers of any similar peacetime period, according to S. M. Rust, Jr., vice president of The Rust Engineering Company. This building will start in large volume immediately after



The invention of the lathe made the Machine Age possible and its development still paces the progress of industry. As the accuracy, speed, and versatility of the lathe have improved, industry in general has progressed.

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war restrictions are relaxed, as industries rush preparations to skim the cream from huge pent-up post-war markets, Mr. Rust says.

Thousands of inquiries and orders for designs of new plants and alterations of existing plants have been and are being received by engineering firms throughout the country, Mr. Rust states, providing a solid, factual basis for his assertions.

The types of designs most usually sought, he further comments, are "master plans"—not for single structures—but covering all the building and development contemplated by the firms concerned for five or more years.

"Contrary to popular belief, our tremendous construction of war plants will not halt or make unnecessary extensive post-war industrial building," Mr. Rust continues.

"The effect will be just the opposite. The huge competitive potentialities of these plants will force industrial management to modernize to the limit and to build many entirely new plants in order to stay in the running.

"The combination of this biggest production capacity ever known, the biggest consumer market (as verified by research polls), and most extensive launching of new materials and products, represents the key to post-war industrial construction."

PHOTOGRAPHING THE UNSEEN

Achieved by New High-Speed Method

A PHOTOGRAPHIC technique has been worked out that is so sensitive it could presumably take a picture of a ghost, if there were such things. This new process, utilizing flashlight with an exposure of less than one millionth of a second, photographs things which are invisible, such as the finest details of air disturbances even to the extent of making an image of a heat wave rising from the palm of one's hand.

At present the development is being used for many important war projects which cannot be revealed for security reasons. It is expected, however, to have unlimited peace-time applications where air and gas flow problems are encountered.

When photographs of very rapidly changing conditions are made, an extremely short exposure is necessary to show detail. In this technique such a limitation is overcome by use of a new electronic device which not only supplies the illuminating flash at the right instant, but also gives an exposure duration so short that light from the flash has time to travel only a thousand feet.

According to the General Electric engineers who developed the ultra-high-speed equipment, two approaches may be used—the Schlieren method and the shadowgraph method.

Shadowgraphs are made by using nothing more than a film holder and a spark light source with extremely sensitive controls. In the Schlieren method, photographs are made with a highly specialized type of optical system which requires infinitely fine adjustment and manipulation.

Shadowgraphic pictures show only the boundary conditions between regions of sharp variations in density or pressure, such as the difference existing between the air encased in a toy balloon and the air when it is escaping. In the Schlieren technique, however, where the sensitivity is many times greater, gradual variations can be better recorded as they occur throughout the region being investigated. Thus, if disturbances of a minor nature are to be recorded, such as that of breath coming from the nostrils, Schlieren apparatus is used.

Either system may be employed to photograph sound waves or shock waves, provided a sufficiently short photographic exposure can be obtained. If strong disturbances, such as shock conditions in a high-velocity air jet, are to be studied, then the shadowgraphic technique is generally adequate.

UNIVERSITY RESEARCH

Holds Many Advantages For Industrial Organizations

"INDUSTRY has begun to appreciate the service that university laboratories can provide," Dr. Harvey A. Neville, head of the Lehigh University department of chemistry said recently when referring to a 500 percent increase in chemical research contracts since 1940 at that university.

"There is an increasing realization," Dr. Neville continued, "that certain types of research can be conducted more effectively in these laboratories where the academic atmosphere, isolated from production, allows a fresh perspective."

Explaining that 17 new co-operative contracts had been received in his department since the war began, the Lehigh scientist also pointed to values gained by colleges which undertake such researches.

"Professors engaged in co-operative research transmit to their students personal enthusiasm for development," he added. "The advanced undergraduate likewise may share the experience of research by working with his professor on these projects."

New projects in Lehigh's department of chemistry and chemical engineering include those for the Armstrong Cork Company in analytical and leather technology research, the Bethlehem Steel Company in physical chemistry and chemical engineering, and the Catalin Corporation of America in synthetic resin studies.

Among other recent projects are those assigned by the Koppers Company for study of applications of coal tar derivatives and by the William S. Merrell Company, manufacturer of pharmaceuticals, which is supporting research in organic chemistry.

The Raybestos-Manhattan Company's continuing research project is devoted to plastics materials and the National Oil Products Company has also maintained a contract for studies in its field since the pre-war period.

New Products

ALUMINUM DRUMS

DEVELOPMENT of a light-weight aluminum drum to expedite transportation of aviation gasoline over the "hump" to Allied fliers on the China front was announced recently by officials of the Aluminum Company of America.

An allotment of drums, accepted by the Army following exhaustive research



"Flying drum" is light in weight

and tests, has been flown by the Air Transport Command direct to India in order to step up the supply of gasoline needed by the 14th and 20th Air Forces.

With Japan in control of the Burma road, ingenious military men had to take to the air to fly supplies to the Allied fighting front in Asia, and the aluminum gasoline tank—which weighs 21 pounds compared with the 52-pound weight of the old-style regulation drum —was the answer.

The saving in weight will increase the supply of gasoline to the Chinese front many hundreds of thousands of gallons each month, engineers estimate.

VERSATILE SYNTHETICS

THE story of the synthetic resin that out-performed rubber is the story of the compar washers, seals, gaskets, diaphragms, and similar flexible moldings that are being turned out for a wide variety of industries by Resistoflex



They wear better than rubber

Corporation, developers of compar. Though the first moldings of this vinyl resin derivative were not compounded to take the place of rubber, it has now been demonstrated that compar outperforms rubber in many applications where its use has now become standard.

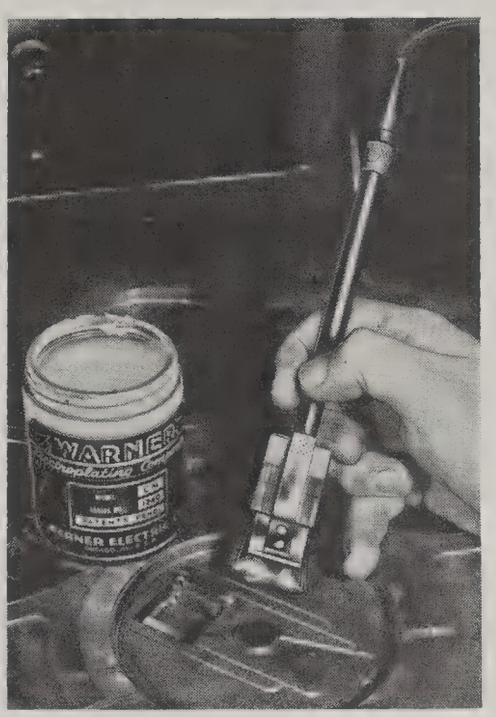
Molded compar is capable of many variations which give the exact degree of flexibility, elasticity, and abrasion resistance required for each particular application and is widely used in such fields of manufacture as machine tool, radio, automobile, aviation, Diesel engine, x-ray, road-building machinery, air-conditioning, and refrigeration.

The compar parts have a service life from 5 to 250 times that of rubber and exhibit the same outstanding characteristics of inertness to organic solvents, abrasion, and flexing as do Resistoflex oil- and solvent-proof hose assemblies which have as their core an extruded tube of compar.

Especially compounded and engineered for each application, compar washers, seals, diaphragms, and gaskets have proved suitable on instruments, oil and chemical pumps, hydrocarbon and rubber cement bottles and cans, ball mills, spray guns, fire extinguishers, and oil cups on hydraulic presses.

PORTABLE ELECTROPLATER

A NEW and improved electrolytic brush, used in conjunction with electroplating compounds, has now become available



Worn parts and shafts may be renewed with this electrolytic brush

for peacetime production. With the cooperation of Du Pont, it was developed by the Warner Electric Company to solve specific electroplating problems.

The new brush and process are now



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were prepared before the war, without the slightest thought of sale to professionals. Came the war. Hundreds of new optical industries sprang up. Fewer amateurs found time to make telescopes yet sales of these books increased! Investigation of sales revealed that the new industries were buying them by the hundreds

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For their Workmen

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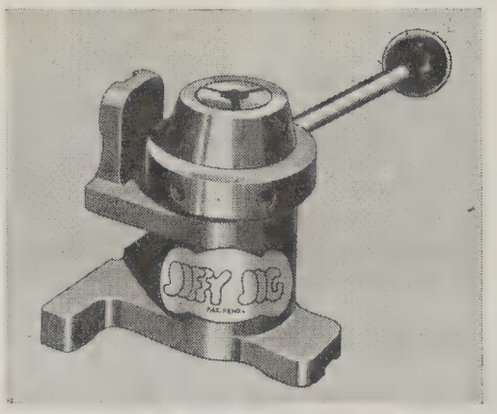
being employed in an increasing number of industrial applications. This method has proved practical and demonstrated its usefulness in decorative work, maintenance, and in salvaging tank-plated rejects.

Immovable objects may be electroplated without being dismantled. A company's name or trade mark may be electroplated on the article being manufactured. The conductivity of electric switch contacts, blades, and jacks may be improved or renewed without disassembly. Dies and shafts may also be plated and renewed when worn.

COLLET CHUCK

A LEVER-OPERATED chuck with a capacity for stock ranging from 1/16 to 1 inch in cross-section, and known as "Jiffy Jig" model J-10, is announced by the Monarch Governor Company. Readily adapted to various machine tools for drilling, milling, boring, grinding, and so on, this chuck can be set up in either horizontal or vertical position.

It has been designed to provide ample chip clearance and when the chuck is either open or closed, the collet is



Horizontal or vertical operation by lever makes this collet chuck handy

stated to have absolute zero axial movement and positive axial dimension control. The "Jiffy Jig" consists essentially of three parts—cap, base, and operating lever, the taper on the cap conforming to that of the collet. With the proper sized collet in place, the cap is screwed down on the base until the collet opens and closes as desired. The operating lever is then screwed into place and the chuck is ready to use.

TIMER

MANUALLY preset, an interval timer having wide application has just been announced by the Paragon Electric Company. The new model, #2500, can be preset to allow a given operation to continue for almost any pre-determined time limit; and to close or open a circuit at the end of the preset time.

This unit is adapted for use in plastics molding, rubber curving, batch mixing, heat treating, enamel baking, liquid agitation, light exposure, blower, pump, and conveyor operations, watchman signals, food cooking, power and light disconnect, machinery operation, control of ventilating fans on a preset schedule, and night heating shut-down.

Engineered features include: (1) Single-pole, double-throw, 1000-watt capacity switch, fully enclosed, underwriters approved. (2) Only two exposed gears—motor pinion and wheel, precision hobbed. (3) Self starting motor, slow speed synchronous, completely sealed. (4) No energy is required of clock motor to trip switch at end of preset time. (5) Ten time ranges from 0 to 15 seconds through 0 to 20 hours. (6) All parts rust proofed and protected against corrosion.

The #2500 series can be mounted on the surface of any panel or directly on the surface of the equipment the timer is to control. It is also designed to be mounted directly over and to any standard single-gang switch box or handy box. Available for flush mounting or wall mounting with conduit connector.

WELDING CLAMP

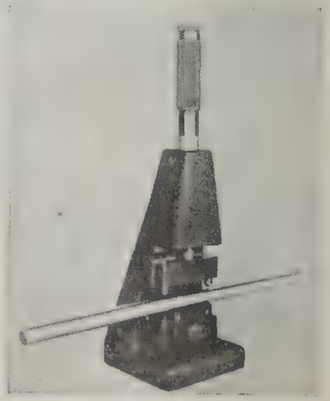
A NEW low-cost ground clamp for welders has been announced by The Lincoln Electric Company. Besides its low cost, the clamp has the advantage that each jaw connects independently to the ground cable. Thus, if one jaw is prevented from making a good electrical contact, due to heavy scale, paint, and so on, the other jaw will carry the current.

The ground clamp has a heavy-duty processed steel frame with durable copper conductors and contacts. The unit weighs only 1½ pounds, has a maximum jaw spread of 2½ inches, and a rating of 300 amperes.

CENTER PUNCH

A GAGE point punch which is double-acting and on which impact force is adjustable for different materials has been made available by the Baldwin Locomotive Works. It is offered to the metals field for four reasons: (1) it marks four uniform centers on specimen with one push of the handle; (2) it automatically centers either round or flat specimens; (3) the impact force is applied manually by an adjustable detent which eliminates the use of a hammer; (4) impact and size of punch marks are adjustable to suit soft and hard specimens.

The upper punch holder, guided in a heavy frame, is attached to the impact-adjustable handle. The entire upper point assembly is spring supported to keep the gap between punch points open for the largest specimen. When the specimen is placed on the support, the upper handle is pushed down until all punch points rest on it.



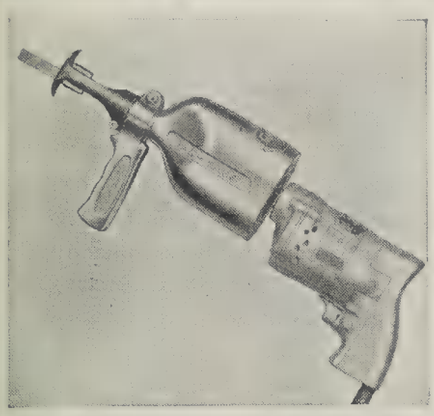
The impact force is adjustable on this gage point punch

A continued push downward on the handle brings to a preadjusted compression a second spring within the tubular knurled handle, releasing potential energy to produce impact on the specimen.

SAW AND FILE ATTACHMENT

An attachment for electric drills that provides a portable power saw and file is sold under the trade name of Saw-Chief.

According to the manufacturer, the



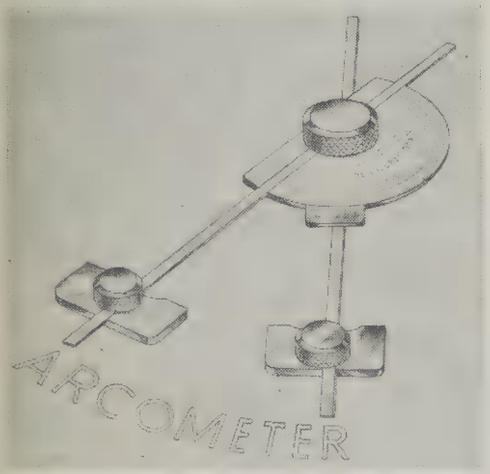
Utilizes electric drill for sawing

Chicago Precision Equipment Company, the new device will rapidly saw every kind of metal, wood, plastics, and other material, by placing an ordinary hack-saw blade in the holder with the teeth toward the operator. It may also be converted into an automatic file by inserting a file in the same chuck or holder.

The inner mechanism of the Saw-Chief is of balanced ball bearing construction, built for heavy-duty cutting and to withstand hard use. The pistol-grip handle permits the operator to guide and hold the device with ease.

MEASURING ARCS

Tool shops and machinery builders of all kinds will be interested in a new device called the Arcometer for measuring arcs along the circular edge,



Saves time in machine measuring

either internal or external, of a surface. With this instrument, shown in the accompanying illustration, it is possible to save time and increase accuracy in the layout of bolt holes on flanges, spacing ribs on cylindrical bodies, and spacing blades in impellers and the like.

In operating the instrument, the corners of the heads are brought against the edge of the work, and the arms are rotated to the proper angle where they are locked with a single thumb-screw. The reference edges of the arms are then used as scribing edges, or for alining parts, as required.

LIGHT WORK GOGGLES

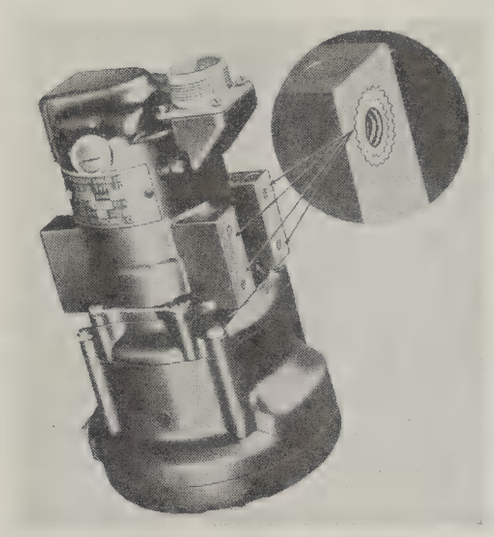
Full protection from impact, dust, flying sparks, and chips is offered by a new work goggle having wide view plastics lenses yet weighing less than one ounce. These goggles fit closely over the nose, brow, and cheeks. They are large enough to be worn over prescription glasses and have ample air space to prevent fogging.

SOFT METAL FASTENING

The motor shown in the illustration, designed for actuating cowl flaps and air cooler flaps on the PV-2, required a rigidly secure mounting in the plane. Since the metal of the mounting boss was too soft to assure permanent fastening, Rosán standard locked-in inserts were installed to give this soft metal the fastening strength of steel.

According to The Dumore Company, who manufacture these motors, Rosán inserts simplified production of the motor and made installation more durable.

These inserts consist of two pieces: A threaded insert with a serrated collar



Locked in securely, these inserts permit mountings on soft metals

and a locking ring which is serrated inside and out. The insert is screwed into a counterbored tap-hole flush with the surface of the parent material. The ring is then pressed or driven into the counterbore. The inner teeth of the ring engage the serrations on the insert collar, while the outer teeth broach the wall of the counterbore and lock the insert in place.

COIL INSULATION

Vacuum impregnation of coils, armatures, transformers, and so on, under pressure, is demonstrating many advantages over ordinary dipping, and costs no more, according to Vacuum Impregnating Works.

Among the results claimed, in addition to more efficient insulation, are: higher sustained voltages without overload; elimination of wear due to creep-

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What Strange Powers Did the Ancients Possess?

EVERY important discovery relating to mind power, sound thinking and cause and effect, as applied to self-advancement, was known centuries ago, before the masses could read and write.

Much has been written about the wise men of old. A popular fallacy has it that their secrets of personal power and successful living were lost to the world. Knowledge of nature's laws, accumulated through the ages, is never lost. At times the great truths possessed by the sages were hidden from unscrupulous men in high places, but never destroyed.

Why Were Their Secrets Closely Guarded?

Only recently, as time is measured; not more than twenty generations ago, less than 1/100th of 1% of the earth's people were thought capable of receiving basic knowledge about the laws of life, for it is an elementary truism that knowledge is power and that power cannot be entrusted to the ignorant and the unworthy.

Wisdom is not readily attainable by the general public; nor recognized when right within reach. The average person absorbs a multitude of details about things, but goes through life without ever knowing where and how to acquire mastery of the fundamentals of the inner mind—that mysterious silent something which "whispers" to you from within.

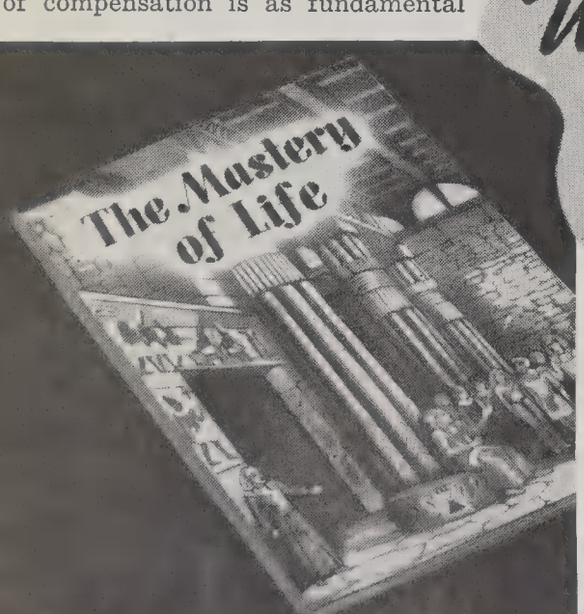
Fundamental Laws of Nature

Your habits, accomplishments and weaknesses are the effects of causes. Your thoughts and actions are governed by fundamental laws. Example: The law of compensation is as fundamental as the laws of breathing, eating and sleeping. All fixed laws of nature are as fascinating to study as they are vital to understand for success in life.

You can learn to find and follow every basic law of life. You can begin at any time to discover a whole new world of interesting truths. You can start at once to awaken your inner powers of self-understanding and self-advancement. You can learn from one of the world's oldest institutions, first known in America in 1694. Enjoying the high regard of hundreds of leaders, thinkers and teachers, the organization is known as the Rosicrucian Order. Its complete name is the "Ancient and Mystical Order Rosae Crucis," abbreviated by the initials "AMORC." The teachings of the Order are not sold, for it is not a commercial organization, nor is it a religious sect. It is a non-profit fraternity, a brotherhood in the true sense.

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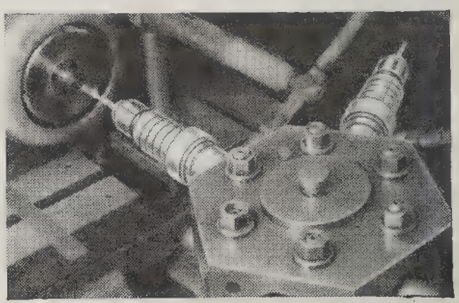
ing of coils; prevention of insulation charring; protection of wires from vibration; permanent filling of spaces; maintenance of coil coolness; coils rendered positively moisture-proof; protection of windings from electrolysis.

Insulation material is suited to each individual type of work. Under the process employed, insulation is guaranteed to the very center of the unit impregnated.

PNEUMATIC SCREW MACHINE

A NEW line of air drills, designed for use on hand and automatic screw machines, is announced by Keller Tool Company.

These drills may be mounted in the regular tool holders of automatic or hand screw machines. Compressed air is fed to the drill through a valve arrangement which opens as the turret moves forward and closes immediately when the turret is backed away from the work.



For increasing drilling speed

Drilling speed may be increased with Keller pneumatic screw machine drills by 1200 to 3500 revolutions per minute. The entire time cycle of parts manufacture that was formerly held up by the drilling operation is thereby improved. This is of advantage when drilling small, deep holes on the larger type of screw machines, where the spindle speed of the machine is too slow to produce a satisfactory cutting speed.

Holes drilled by this method will not "run out," since the air drill spindle revolves in a direction opposite to the direction of the work in the screw machine spindle. This results in a true hole and reduces drill breakage.

The new Keller screw machine drills are available in three sizes and eight models, having speeds of 1200, 2800, and 3500 revolutions per minute. Drill capacities range from 1/32- to 3/8-inch diameter twist drills.

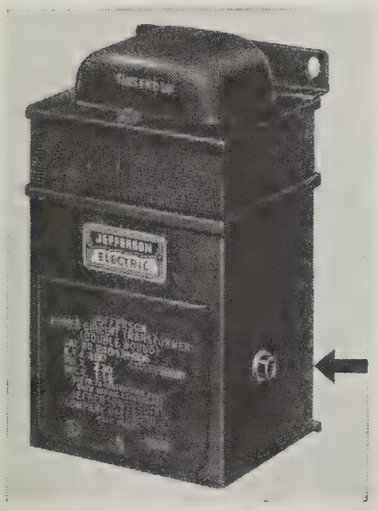
TRANSFORMERS

POWER-CIRCUIT transformers, made by Jefferson Electric Company, in capacities from 100 to 750 watts, are now available with simple, effective circuit breakers for overload and short-circuit protection. Transformers of these capacities are used extensively, mounted directly on machines to step down the 550, 440, or 220 volts to 110 volts for various electrical appliances and lights.

This type of transformer, in connection with remote control stations, meets electrical safety standards of the National Machine Tool Builders Association. Flexible cable or conduit may be

run from the wiring compartment to motor or appliance. Transformers can be furnished with "on" and "off" switch and receptacle in the wiring compartment, a feature that is desirable when serving small wattage appliances or individual lamps.

The circuit breaker is tamper-proof,



Completely protected

being completely housed in the transformer case with the reset button extending as shown in the illustration. For 25- to 75-watt transformers, with their light loads, fuses are provided in place of circuit breakers.

LUBRICANT

An improved line of industrial and automotive lubricants, processed with Bonoleum, holds promise of significant advances in the oil industry.

Bonoleum is an oil ingredient which acts as a film strengthening agent impervious to chemicals, heat, or acid. It is compounded with a castor-oil essence from which the gum-forming ingredients have been removed by secret processes. Bonoleum is reported to eliminate surface tension and assure a transparent, free-flowing lubricant.

Certain medicinal qualities in Bonoleum are claimed that make it actually beneficial to the skin, preventing infection, and decreasing industrial absenteeism due to occupational dermatitis.

DIP TANKS

Processing tanks and kettles, designed around the two basic principles of direct and indirect heating methods, with a choice of either gas or electricity as the heating medium, are announced by the Castaloy Corporation for the purpose of melting, blending, and compounding plastics and chemical formulations. They are especially adapted to "hot dip" plastics packaging, a process used extensively during this war for shipping spare parts and for similar applications.

The indirect heating method is accomplished by enclosing the plastics container within a considerably larger vessel which contains Dowtherm E. The two tanks form an integral welded, leak-proof, hermetically sealed construction. Dowtherm E boils at 350 degrees, Fahrenheit, and at 390 degrees the vapor pressure is approximately 10 pounds (24.6 pounds absolute). By controlling the vapor pressure, the temperature range is maintained within very close limits.

Direct-heated equipment is controlled by means of thermostats mounted on each electric heater to maintain the sheath temperature within predetermined range plus or minus 10 degrees, Fahrenheit. This method provides the correct combination of ambient and sheath temperature that is required to maintain the tank wall at the maximum safe temperature. A relay "cuts-off" all heaters when the desired temperature is reached.

A thermostat bulb is located within a special wall, mounted within the bottom of the tank, where the correct batch temperature is constantly controlled. A green light comes on when the batch reaches the dipping temperature, and a red light indicates the "idling" or below dipping point.

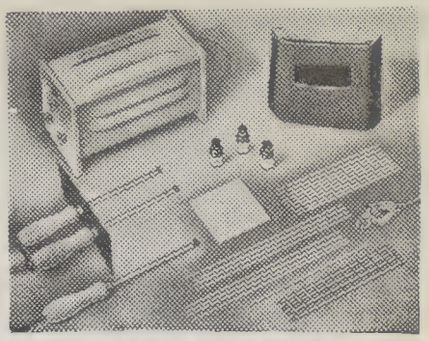
BEARING

The largest bearing — weighing 96 pounds — ever produced by powder metallurgy exemplifies progress in this



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relatively new art. Oilite bearings of this size, produced by Chrysler Corporation's Amplex Division, can be machined from the latest and largest Oilite cored bars now being produced. A striking contrast to the huge bearing shown in the accompanying photograph



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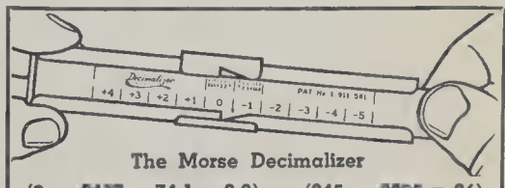
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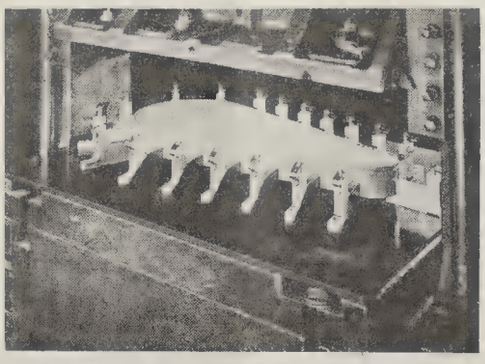
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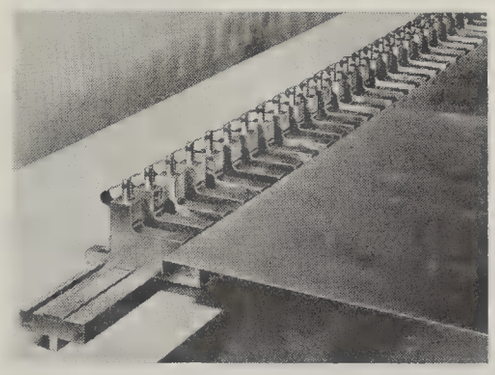
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may be had by recalling that the maximum size of bearings produced by powder metallurgy only a few years ago was less than five pounds.

HORIZONTAL HOLE PUNCHING

ANNOUNCEMENT of a new hole-punching technique with Wales horizontal type "H" hole punching units has been made by George F. Wales, president of the Wales-Strippit Corporation. These units are designed for punching





Above: Hole punching units with work nested in position. Below: Another type of set-up showing the punches laid out on a rail

holes in flanges, angles, container sides, and similar shaped and formed work. Each unit is independent and self-contained, which permits the same group of units to be used and reused, placed and replaced on press brake rails and on templates in stamping presses to punch unlimited straight-line patterns. The minimum center-to-center distance is ⅞ inch. Punch, die, guide, and stripper spring are held as an independent, self-contained unit by the holder.

This holder keeps the punch and die in perfect alinement, eliminating hours, and sometimes days, customarily required to aline conventional dies. This feature also reduces press "down time" to an absolute minimum. Nothing is attached to the press ram. All that is required to make a set-up is to place the units in position according to a master pattern and start punching at the first stroke of the press ram without any further adjustments.

STEAM-SET INKS

DEVELOPMENT of a new synthetic resin binder for the ink maker, which gives a carefully balanced water tolerance and excellent stability on the press rolls to the steam-set inks now widely used on paper bottles, folding box cartons, and food wrappers, is announced by the Resinous Products and Chemical Company. Known as Amberol 820, this synthetic binder is a hard, high-melting resin which demonstrates infinite solubility in diethylene glycol, excellent humidity tolerance, and high resistance to petroleum and hydrocarbons.

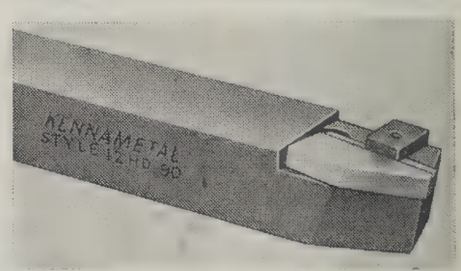
Steam-set inks are a fundamentally different type in that they do not oxidize nor do they utilize a solvent which must be driven off. Their lack of odor, extreme cleanliness, brilliance of color, non-rub characteristics, sealing properties, and elimination of offset have led to their widespread use. Since many foods—butter, lard, bread, and milk—show tendencies to pick up residual odors in printing inks, the lack of odor in steam-set ink is particularly important.

These inks consist of pigment, a resin binder, and an odorless, high-boiling-point organic solvent. In order to function properly, the resin binder must be soluble in the solvent and in a mixture of the solvent and a limited quantity of water, but insoluble in a mixture of the solvent and an unlimited quantity of water. When a film of the varnish formed from this resin and solvent is subjected to an unlimited quantity of water, a thin, hard film is formed over the underlying portion which is plastic and adheres to the paper. The formation of this hard surface prevents any offset or transfer of ink from the printed surface.

The resin is prepared by dissolving it in diethylene glycol with heat to give a clear solution. The method of preparation has little or no effect on the final vehicle and the heating schedule can be selected on the basis of convenience. A typical formula utilizes 100 pounds of Amberol 820 and diethylene glycol and requires heating for approximately ten minutes at 300 degrees, Fahrenheit, to obtain a clear solution. The resin shows no tendency to separate after even several months' storage.

CLAMPED-ON TOOLS

HEAVY-DUTY machining on steel castings and forgings, and cast iron, can be accomplished with minimum tool stocks



Cutting edge clamps on

by the use of new Kennametal Clamped-on Tools. This design has been made possible by the development of heavy-duty tips which, while overhanging the tool shank by about 1/16 inch, have ample strength for heavy feeds and deep cuts.

These new tips have a clamping shelf along the top of the side opposite the cutting edge. When dull, the tip is advanced and resharpened. Only the cutting edge is ground and no steel is removed from the shank.

Current Bulletin Briefs

Conducted by
K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

HOW TO RUN A LATHE is a 128-page, thoroughly illustrated manual on the care and operation of a screw-cutting lathe. Now in its 42nd edition, this book has been proved in practice and is widely accepted for its accuracy and clarity of detail. All phases of the work are considered, including special types of operation. Shop "kinks" and "don'ts" are featured. *South Bend Lathe Works, South Bend, Indiana.—25 cents, paper covers; 75 cents, leatherette covers.*

V-BELT HANDBOOK FOR INDUSTRIAL APPLICATIONS is a 74-page booklet containing data on the whole subject of V-belts including their advantages, installation and care, varieties obtainable, and the qualities to seek when selecting various models. *The B. F. Goodrich Company, Akron, Ohio.—Gratis.*

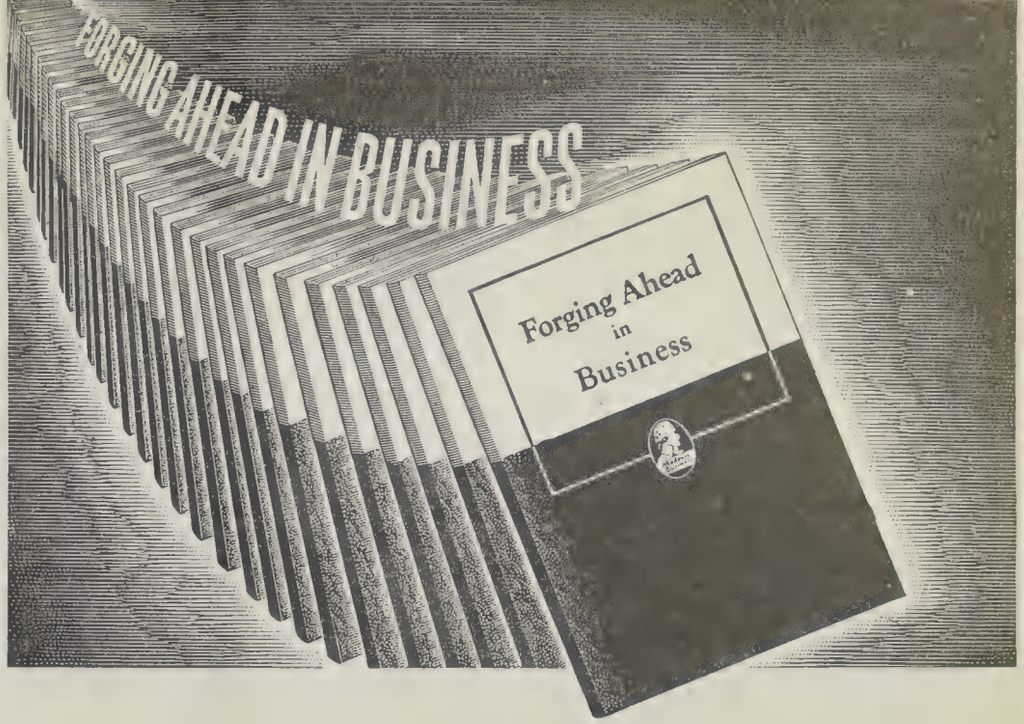
PANTOGRAPH ENGRAVING MACHINES is a 20-page booklet based on the specifications and applications of standard models as well as seven other machines for special purposes. Request Bulletin 1580-B. *George Gorton Machine Company, Racine, Wisconsin.—Gratis.*

DITCHING WITH DYNAMITE is a 32-page illustrated booklet, the product of years of experience in the field and in the laboratory, giving a complete explanation of a technique being widely used in agriculture, pipeline and highway construction, and mosquito and flood control. *E. I. du Pont de Nemours and Company, Inc., Explosives Department, Wilmington 98, Delaware.—Gratis.*

ROTARY FILES WAR SUPPLEMENT is a 10-page folder describing more than 72 rotary files of various shapes, both hand-cut and ground from the solid. Diameter, length of cut, and price of each is listed. *Grobet File Company of America, 421 Canal Street, New York 13, New York.—Gratis.*

THE SECOND MILE, A RE-SURVEY, 1944, by W. E. Wickenden, is a 16-page pamphlet written to present the engineering profession to the young engineer and also contains information pertinent to all engineers. *Engineers' Council for Professional Development, 29 West 39th Street, New York 18, New York.—Single copies ten cents.*

SHOT PEENING AND THE FATIGUE OF METALS, by H. F. Moore, is an illustrated booklet based on the findings of laboratory research. Some of the subjects covered are: Types of structural



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JIFFY JIG FOR DRILLING, MILLING, BORING, AND GRINDING is a four-page circular describing and illustrating the four standard set-ups of this new type of lever-operated chuck. Stock size capacities and other pertinent information is given. *Monarch Governor Company, 1832 West Bethune Avenue, Detroit 6, Michigan.—Gratis.*

PULL-UP BROACHING MACHINES BY COLONIAL is a 16-page bulletin describing the standard pull-up machines, tools, and attachments. A section is devoted to the basic tooling of the machines and specification tables with drawings of machines, tools, and attachments are presented. *Colonial Broach Company, P. O. Box 37, Harper Station, Detroit 13, Michigan.—Gratis.*

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AEROIL HOT LIQUID DIP TANKS (GAS FIRED AND ELECTRICALLY HEATED) are two 16-page catalogs giving complete specifications on insulated hot dip tanks that are fueled by city gas, natural gas, or electrically heated with thermostatic controls. *Aeroil Burner Company, Inc., Box BG, West New York, New Jersey.—Gratis.*

ARRIVING SAFELY PROTECTED BY MYSTIK SELF-STIK is an illustrated booklet designed to give plant executives specific ideas on how they can use self-sticking industrial tapes in a wide range of applications. *Chicago Show Printing Company, 2635 North Kildare Avenue, Chicago 39, Illinois.—Gratis.*

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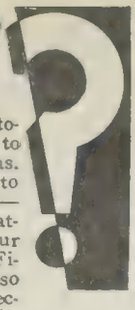
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READERS of this department will recall a discussion of air currents in reflector tubes, by F. N. Hibbard, of Richmond, Virginia, in the January 1944 number. The following discussion of this subject is by E. K. White, Chapman Camp, British Columbia, and is reprinted from *The Journal of the Royal Society of Canada,* Toronto, Ontario.

"PRESENTED in this article are the results obtained from experiments made with an electric fan forcing a current of air into the metal tube of a Newtonian reflector.

"The telescope is of 9" aperture, and 100" focal length, and is used chiefly for the study of lunar and planetary detail. The tube is of iron, 10" in diameter and 104" long. There are no ventilation holes in the tube, save for a narrow space between the wall of the lower end of the tube and the mirror cell. When not in use the instrument is housed in a roll-off wooden shelter.

"It is well known that many observers are of the opinion that closed metal, and even closed wooden, tubes have a detrimental effect on the seeing, the reason being assigned to the presence of air currents within the tube of a different temperature from that of the outside surrounding air. Possibly the best remedy is an open skeleton-type tube, similar to those of the large reflectors. However, one living in a damp climate, as prevails in most of southern British Columbia, will have severe dewing and frosting conditions to contend with unless the mirror is removed to the house when not in use; and this method is bad for the silver film. The closed tube insures freedom from dewing of the mirror and prevents trouble from stray light; also, it aids in keeping the mirror free of frost crystals in winter.

"The late W. H. Pickering, ('Amateur Telescope Making—Advanced,' pages 610-612), well known lunar and planetary observer, claimed greatly improved seeing with closed tube reflectors by forcing a stream of air through the tube, introducing it by means of a small fan near the mirror's surface, and expelling it out of the open end. Here is movement of air within the tube, but of the same temperature as that outside. In other words, the troublesome warmer or colder air in the tube is displaced by outside air. Of course, the fan must be kept running as long as observations are made.

"By way of experiment, a round hole 5" in diameter was cut in the lower wall of the tube, just above the surface of the mirror. This is covered by a metal hinged door, having a close-fitting felt gasket. A 5" electric fan was obtained and experiments started.

"At the beginning of observations the extra-focal rings of a bright star, usually Polaris, were noted. Immediately the tube door was opened these rings became much distorted and unsteady. When the fan was started the rings became circular again and steadier, but they always showed a rapid rotation in the direction of the fan blades. With the fan running, the rings were definitely steadier than when the fan was off but the door open.

"The definition of detail on the moon and the planets Saturn and Jupiter was studied, with and without the fan, in all conditions of seeing the skies afforded. It was impossible to note any improvement with the fan on these objects, when the seeing was between 0-4 (scale of seeing objects devised by W. H. Pickering—0 very poor, 10 excellent). However, on a few occasions when seeing was estimated to be from 5-7, a very slight improvement in definition seemed certain when using the fan. The floor of the lunar crater Plato under oblique lighting was used as a test, and on good nights from two to four craterlets could be seen as such. With the fan running, these marks were steadier although no more fine details could be seen than before. No further detail could be seen on the planets mentioned, simply a steadying of the difficult marks seen without the fan. No improvement could be noted in the resolving of close double stars in any condition of seeing, but little time was spent with this particular investigation.

"The fan must be mounted on an adjustable stand, and not attached to the tube, so as not to set up any vibrations in the instrument. The blades should be kept close to the tube opening, in order to have a maximum current of air flowing through it. These requirements introduced some inconvenience in any careful observing program by necessitating rather frequent adjustments of the fan as the drive carries the long tube forward.

"From results so far obtained, with the exception of rare nights when seeing is quite good, the use of a fan is not considered worth while as a measure to improve definition. While it is known that other observers than W. H. Pickering have claimed that the use of a fan gives marked improvement in definition, I have unfortunately been able to find little published of their findings, or methods. Further experiments with a fan are being continued at this station."

THE FOLLOWING is the remaining part of an article begun last month by Daniel E. McGuire, on the use and technique of scotch-tape spacers for speeding up the previously tedious task of testing optical surfaces by means of interference fringes:

The collimating lens system can be computed by graphic ray tracing. This is done for a zone about 90 percent of the way from center to edge of the test plate surface. This zone focuses to the center of the smallest circle of confusion in the image formed at the viewing distance. The single surface collimator is easiest to compute by graphic ray tracing (Figure 3). It is much more difficult to determine the amount of curvature required for the two lens collimating system, especially when both curved surfaces are required to have equal radii in order to simplify tool making.

The designing may be simplified by selecting a curvature for the back of the test plate which deviates the ray through approximately one third of the angle required to focus to the eye position. The flat surface of the auxiliary lens further deviates this ray. The last step is that of finding the radius required in the third surface to deviate the ray still farther, so that it crosses the optical axis at the required viewing distance. In the first and third steps, an unknown curvature is determined by means of a known index of glass and a known deviation. In the second step, an unknown deviation is determined by means of a known index and curvature (or flatness) of the glass. Only the first step is used with the simpler system.

The two diagrams in Figure 3 show how to determine the radius of the single surface collimator. The test plate curvature is indicated by R_1. The clear aperture falls within the dotted line and the 90 percent zone is used in the calculation. The radial line passing through the 90 percent zone locates point P laterally, but its longitudinal position is judged according to the required thickness of the glass at this zone. *PE* crosses the axis at the eye position *E*. Points *A* and *B* are distant from *P* in the same ratio as the refractive index of glass and of air. The index in this case is 1.52, so *PA* equals 1.52 times *PB*. Line *CD* is made parallel to *AB*, passing through point *P*. The center of curvature of the collimating surface, R_2, is found where line *CD* crosses the optical axis.

The concave test plate (Figure 3, left) nearly exceeds the limit of curvature for a single surface collimating system. Spherical aberration is much reduced by using an auxiliary lens.

The convex auxiliary lens must be made larger in diameter in order to include the marginal rays. In Figure 4 the auxiliary lens is too small to illuminate the margin of the test plate, but it is advisable to make the test plate oversized, with illumination over the needed area. In this way, a turned-down edge on the test plate can do no harm; it is masked off, invisible.

The convex test plate is well within the limit of practical design. When it

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is necessary to add an auxiliary lens, it is made still smaller in clear aperture at its back surface to keep its edge thickness to a minimum. Its plane surface rests upon the flat area surrounding the first collimating surface, with the concave side toward the eye. The same rule can be applied, regarding the use of an oversized test plate, to exclude from vision an imperfect margin of the surface.

The 100 percent zone is at the edge

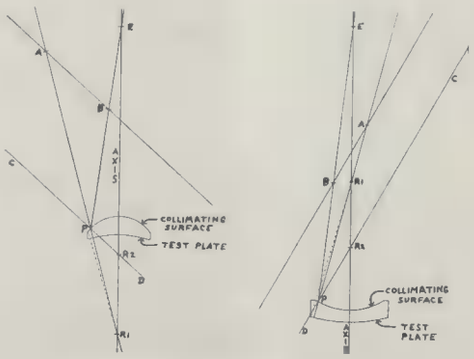


Figure 3: Graphic ray tracing

of the required diameter of test plate surface. An additional 5 percent can be added to the diameter of the polished surface to simplify the making of a perfect surface within the used area. Ray tracing the 100 percent zone shows the required boundaries of collimating lens surfaces.

For a further study of graphic ray tracing through a number of surfaces, see Martin's "Applied Optics," Vol. I, Figure 7.

When designing collimating test plates, it is not desirable to have normal incidence for the marginal rays on any of the collimating surfaces. An optical flat, having a plane-parallel back surface, needs an auxiliary lens to collimate the light; but the light reflected from the back surface is focused at the eye position the same as the light used

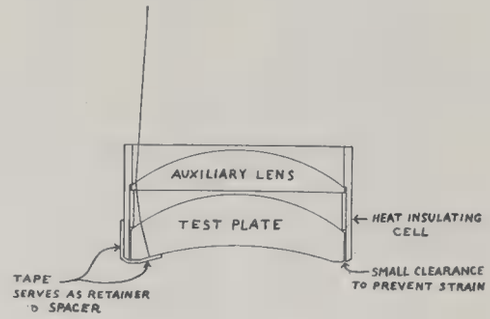


Figure 4: The test-plate cell

in testing. This fogging of the fringe pattern can be reduced by a non-reflective coating on the back surface of the test plate. Non-reflective coatings on all collimating surfaces improve the test when extraneous light from the room is reflected in the surfaces. Reflection of the light source in the center of uncoated collimating lenses is not objectionable.

There are two methods of using the test plates. Figure 1 shows how finished work, or single surface work in process of polishing, may be tested. It is practical only where the work is easily handled by the edges, or by an attachment. The work is viewed in the mirror below. Nothing is reversed in the mirror, since the work is interpreted as though looking down from above. Top, bottom, left, and right are in their respective places. This method eliminates handling the test plate for each test. Only the work is touched, and for a very short period per piece, and thus thermal effects are negligible. Some 300 to 400 surfaces an hour may be tested.

The test, as shown in Figure 2, requires handling of the test plates, but cells of heat-insulating material are used to guard against thermal effects. Thin edged, convex lenses are difficult to test with the arrangement in Figure 1. In Figure 2 they are placed on a padded ring, with the test plate on top, while looking down through the beam splitter.

With sufficient clearance between beam splitter and table, multiple blocks of lenses are tested, as shown in Figure 5. The lenses in the outer row are viewed in turn by rotating the block upon a fixed axis that is set at the proper angle. The block is set with axis coincident with that of the light for testing the center lens, or at a slight angle for an inner row of lenses.

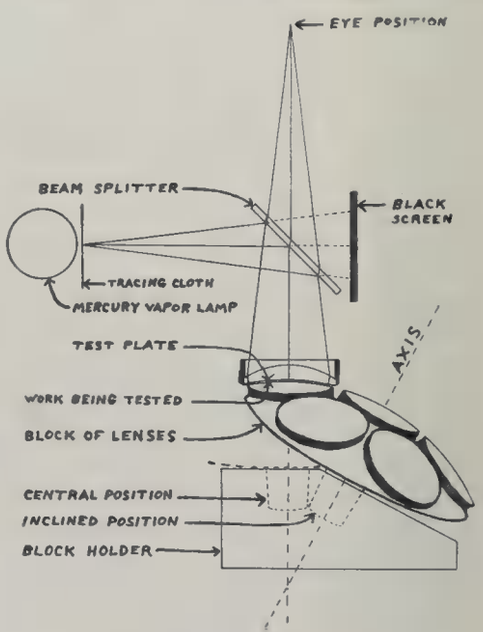


Figure 5: Testing on the block

In order to simplify the drawing, Figure 5, the tool shank is made longer than it ordinarily is. A shorter shank requires a convex block holder to fit roughly into the hollow, curved back of the blocking tool. Tapered holes are bored at the proper places, similar to those shown in the flat sided block holder.

A concave block of lenses requires a concave block holder, or simply a hollow arch, with holes bored at the proper places to line up the various rows of lenses with the axis of the light source. Blocks of flat work are held in place by any one of a number of adapters, all of which are mounted on a flat plate. Small, light-weight work is easily supported in one hand while making the test.

Air-spaced test plates are not entirely new, although the writer may have some original ideas. These, or similar, methods are being used in some optical shops—just how many and in what circumstances is not known.

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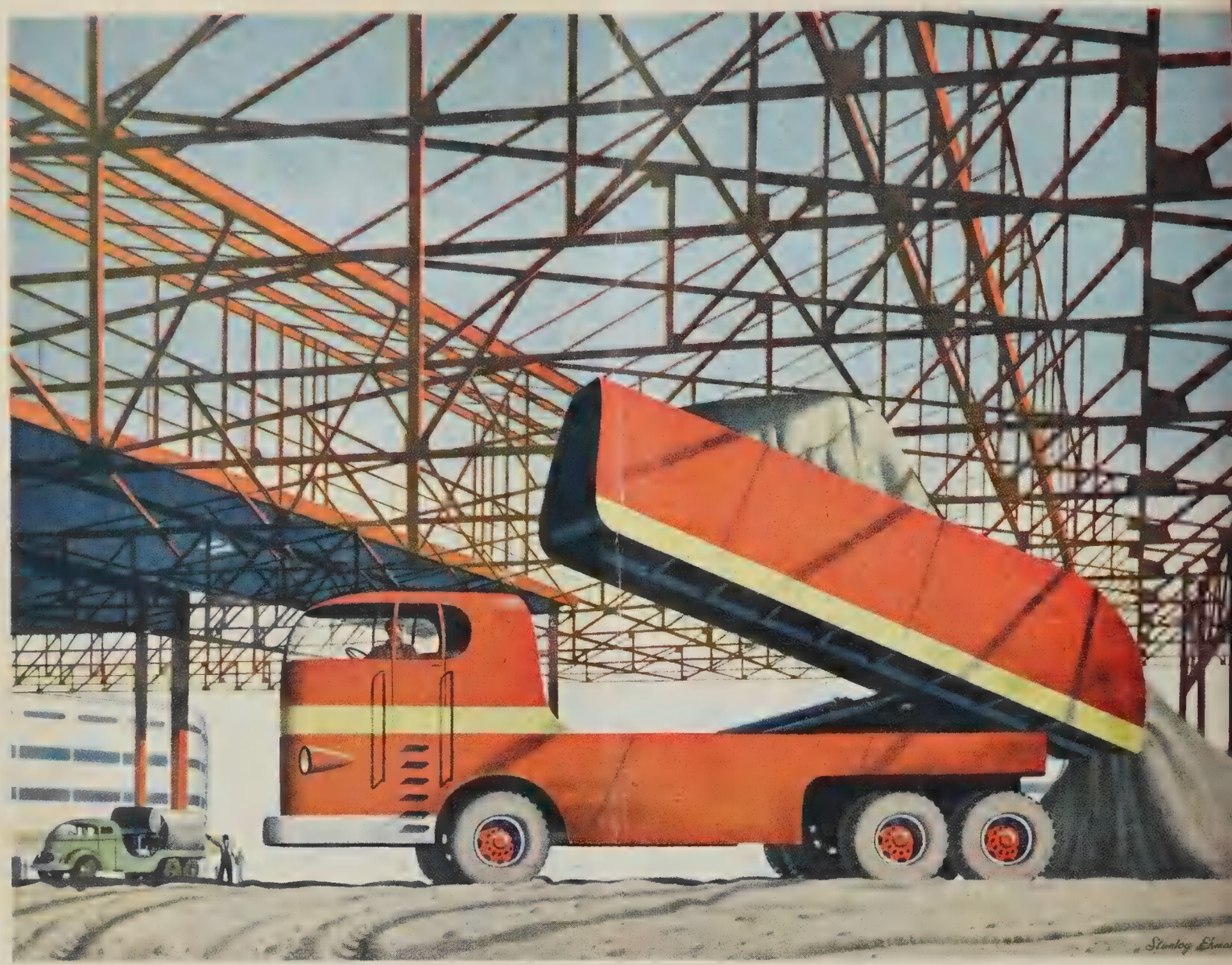
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Scientific American

★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Powered by a Turbine . . . See page 129

The Story of

AMERICAN RAILROADS

Anniversary
Issue
No. 3



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There's no mystery about radio communication for railroads. It's simply a job of putting telephones on freight trains without using wires.

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Our Cover: Fundamentally new in design is the direct-drive steam turbine locomotive, shown on our front cover, a product of Baldwin Locomotive Works, Westinghouse Electric and Manufacturing Company, and the Pennsylvania Railroad. The main turbine is located below the boiler, between the second and third pair of driving wheels.

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Previews of the Industrial Horizon

By A. P. Peck

RAILROADS AT WORK

As Scientific American salutes 100 years of railroad progress with the present number, the railroads themselves are gallantly carrying a war-time burden that has been made doubly difficult by the continuing reduction in the ability of other forms of transportation to operate at normal capacity. Accustomed as the public has become to other forms of surface and air transportation, it has had to fall back more and more on the rails that were so largely responsible for opening the frontiers of this great nation.

Although the operations of the railroads are confined to their rights-of-way, and they lack much of the flexibility of highway transportation, they handled almost three quarters of the nation's inter-city freight during 1943, plus a large percentage of other transportation requirements brought about by the war. With such a record, the future of the railroads seems assured. Those who would point to the air and to the highways as the future transportation thoroughfares that will carry all passengers and freight would do well to pause and reconsider many of the factors that have made the railroads great.

No longer does the stigma of "the public be damned" dominate the operations of the railroads. Such an attitude died with the passing of adolesence—it is a concomitant of growing pains—and has been replaced with the realization that the public must be served. If the reader still doubts, the articles in this issue of Scientific American should do much to dispel the surrounding mists. Industrial co-operation with the railroads, plus the plans of the roads themselves, point up the place of the railroads in the American way of life.

WHO WILL PAY THE FREIGHT?

Without going too deeply into the mire of taxation, subsidies, and so on, it should be noted here that the railroads must be given an even break with other means of transportation. They have paved the way. They have proved their value over more than a century. They can be equally valuable in the strenuous post-war years to come. But they have two strikes against them, strikes that can well vitiate the technological developments which the railroads have initiated and nutured, unless something is done about the umpiring of the ball game. We can do no better in summarizing this sector of the railroad horizon than to quote Gustav Metzman, president of the New York Central System:

"If our government-owned transport plant—our superhighways, our waterways, and our airways—were made really self-supporting, then these developments could be made free from appropriations and from politics. If this were done, private investment in railways could live alongside of government investment in highways, waterways, airports, and airways."

TOMORROW'S HOMES

Everyone knows, apparently, that a big building boom is due just over the horizon. Figures have been quoted frequently on this page, the latest of them being that an estimated 12 million new homes and apartment units will be built in the first ten post-war years. This is a figure that indicates that only Big Business can turn the trick, can throw into the field the resources necessary to provide such capacity of construction. And this naturally brings up the question of pre-fabrication of home units.

Are the American people going to look forward with any degree of anticipation to vast areas built up with homes of identical appearance? Is John Q. Public going to be satisfied with a domicile that looks just like his neighbors', for as far as the eye can see? It is hardly necessary here to record the negative answer.

But Big Business made possible the millions of pre-war automobiles which brought Mr. Public a freedom of movement that he had never known before. It brought him refrigerators, radios, oil burners, and other modern comforts. And it will bring him the benefits of prefabrication without the possible detriments of pernicious uniformity. Our bets for the future of prefabrication go on kitchens, bathrooms, wall units, heating systems, and the like, which can be economically worked into individualistic designs that will make the home of tomorrow a completely livable place, with the distinctiveness that is a requisite of human nature.

RADIANT HEATING

While on the subject of homes, radiant heating should be given a passing nod. This system, in which the heating pipes are concealed in the walls or floors and there are no radiators in the commonly accepted sense of the word, is going to get a big play in tomorrow's homes. Houses equipped with this system are kept uniformly comfortable with thermostat settings of 60 to 62 degrees and the response to sudden temperature changes is remarkably rapid. Put this method of home heating down as one of the brightest spots on the home's post-war horizon.

SYNTHETIC COATED METALS

A process of coating metals with synthetic latex is going to make a strong bid for acceptance in days to come. Originally adopted to eliminate the effects of abrasion and rust as well as acid and alkali corrosion, it also provides a cushioned and non-slip surface for hard metal bases. Thus far, applications have been to filter-press plates, airplane and automobile steering wheels, submarine and other naval equipment, airplane cooling systems, and so on through bolts and nuts and a hundred and one other items.

Through a process developed by United States Rubber Company, synthetic latex—neoprene, buna S, and others—is coated on metal without the use of molds or dies. This method of coating and insulating metal has added advantages wherever the possibility of static electricity sparks would cause explosion, fire, or shock.

FOR FUTURE REFERENCE

A recent survey by the Society of Automotive Engineers shows that popular demand will require that the automotive industry provide more headroom; improved ventilation; more and better gadgets in the form of radios, heaters, clocks, and the like; sound-proofing; more and better vision; narrower fenders; less chromium trim; more durable upholstery; but none of these at the expense of room and comfort for passengers and driver. . . Flying buses or taxicabs, carrying passengers on flights of 10 to 20 miles or more, are no longer in the dream stage, according to a spokesman of Lockheed. . . Says the Better Vision Institute, proposals for highway speeds of 75 miles an hour will increase the work of the "grim reaper" because millions of automobile drivers do not have eyes that can function rapidly enough to drive safely at such speed. . . Tortional vibration in Diesel engines, caused by high compression pressures, are well on the way toward being licked.



to destroy 'em you have to see 'em

Microscopes are gunsights in Medicine's battle on bacteria.

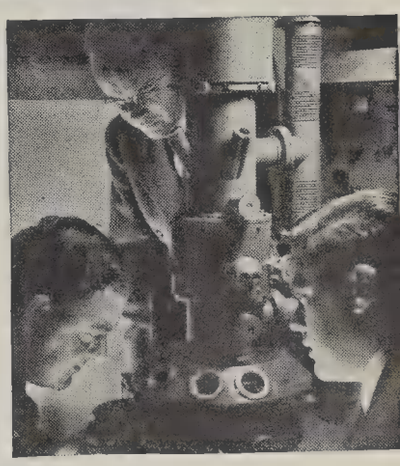
Optical microscopes, however, were not powerful enough to "draw an accurate bead" on the deadly virus that caused influenza.

But today, medical men have seen what no optical microscope could bring into focus—the infinitesimal influenza virus that previously had lain craftily camouflaged among larger cells.

This revelation came about through the Electron Microscope, developed by scientists at RCA Laboratories. And now, having been seen, influenza may be forced to unconditional surrender, saving the lives of thousands each year.

Here is but one facet of the genius shown by scientists behind RCA research . . . the "ever-onward" research that saves lives or creates a better radio with equal skill . . . the "there-when-you-need-it" research that gave super-secret equipment to the United Nations . . . the "way-ahead" research that goes into everything made by RCA.

When you buy an RCA radio or phonograph or television set or any RCA product, you get a great satisfaction . . . enjoy a unique pride of ownership in knowing that you possess the very finest instrument of its kind that science has yet achieved.



They see what human eyes have never seen before!

Drs. Arthur Vance and James Hillier, scientists at RCA Laboratories, with Mr. E. W. Engstrom, Research Director (standing), examine the RCA Electron Microscope that has useful magnification up to 100,000 diameters, revealing unseen new worlds to the eyes of man.

RADIO CORPORATION of AMERICA

PIONEERS IN PROGRESS

RCA

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of March, 1895)

RAIL SPEED — "The first famous record of engine 999 was made May 9, 1893, hauling 362,000 pounds of cars and passengers, the engine and tender weighing 204,000 pounds, the total weight of train being 283 short tons. This train ran on that trip 69 miles in 68 minutes, and during this part of the run made 5 miles in 3½ minutes, or at the rate of 85.7 miles an hour on a descending grade of about 20 feet per mile. During the same run one mile was made in 35 seconds, or at the rate of 102.8 miles an hour. The speed was taken between miles posts with a stop watch by the conductor of the train."

MILLSTONES — "Rock emery forms, as would be expected, one of the hardest, strongest and most cutting and durable millstones. Rock emery millstones are also but a trifle more expensive than the best French buhrs, which is a point in their favor. Rock emery millstones not only displace the French buhr, but also the expensive iron mills recently introduced, which cost from three to five times as much as rock emery mills, and do less work and of an inferior quality."

EUCALYPTUS — "The eucalyptus tree promises to become in time almost as useful to California as the bamboo is to Japan and China. . . It has the advantage of requiring little or no attention and of growing with astonishing rapidity. . . The wood brings a good price when sold for fuel and it is generally acknowledged to have, besides, many valuable medicinal qualities. The eucalyptus is also extensively used to form a windbreak about Californian gardens and orchards."

ARGON — "Thursday, January 31, was an eventful day in the history of the Royal Society. . . Lord Rayleigh startled the world by announcing the discovery of a new constituent of the atmosphere. . . The new gas is called 'argon'; and, so far as is at present known, it stands entirely unrelated to any other substance in nature. . . Its solubility in water is 2½ times as great as that of nitrogen. Examined by the spectroscope, it shows that it has two distinct spectra like nitrogen itself; but while the nitrogen spectra are of different characters, those of 'argon' are of the same type."

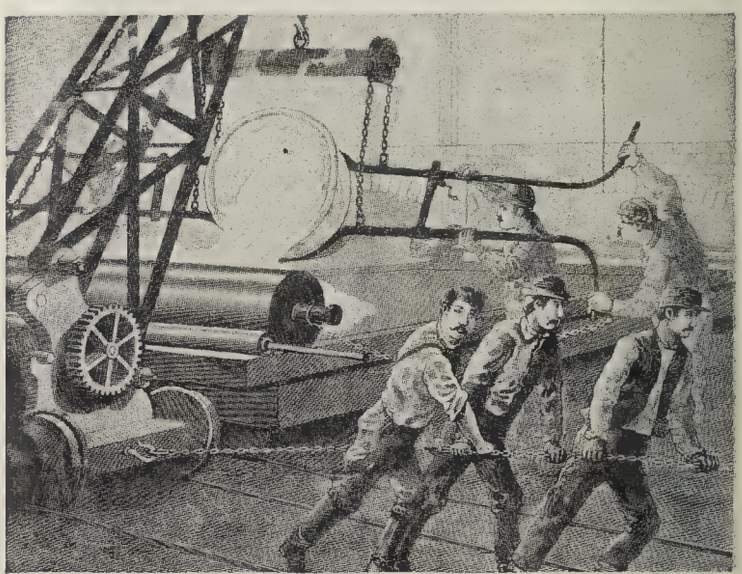
GAGE — "Both pointers of a gage indicating pressure and and temperature are designed to move in unison as long as the boiler is working under normal conditions, the heat indicator hand traveling faster than the pressure gage hand when an abnormal increase of heat takes place in the boiler, an alarm being at the same time sounded."

TESLA — "The attention of the scientific world first centered upon Tesla in 1887 through his invention of the rotating magnetic field for the economic transmission of power. It is believed that Mr. Tesla's experiments were made with a view to saving at least one-third of the energy now wasted in electric lighting. . . He is at present controlling electrical engineer of the Niagara Falls Power Company."

GASOLINE — "The word gasoline suggests danger in the minds of many. It is nevertheless a fact that fewer accidents occur with gasoline engines than with steam power. The very fact that insurance rates are considerably less where gasoline engines are used is evidence that they are less dangerous. It has been but a few years since this type of engine was built in small sizes only, and were not intended to drive machinery of any great magnitude. At the present time, however, they are built in sizes considerably larger than 100 horse power."

SYNTHETIC CHEMISTRY — "A strange conflict is going on just now between nature and science. The field of battle is in the chemical laboratory. Chemistry is making advances along new lines, and products are being obtained by artifice which hitherto have only been known as those of nature. This is the field of synthetic chemistry. Whereas, until recently, chemists have occupied themselves almost wholly with the processes of analysis—that is to say, the taking of things apart—now they are trying to put elements together so as to imitate natural compounds."

PLATE GLASS — "The manufacture of plate glass has attained great development in recent times. It is a striking fact that a material so easily manipulated as glass in the molten state only yields its finest product, plate glass, to the operations



of slow mechanical grinding and polishing. . . The Pittsburgh Plate Glass Company . . . stands as a representative American manufacturer of plate glass, its works being among the largest in the world. . . The material for the plate must be of the utmost purity. . . The first operation after the glass is melted is the rolling. The rolling table is shown in our illustration. It has an iron bed and two rollers are arranged to traverse its surface. The thickness of the glass is regulated by strips of iron which run along the edges of the table, on which strips the rollers rest. The table is mounted on wheels, so that it can be drawn on tracks from one part of the glasshouse to another. A movable crane is shown, which lifts and transports the pots of melted glass."

STEAM SHOVEL — "The primary object of the steam shovel is to supersede hand labor in shoveling; but with the advent of the steam shovel came increased and multiplied opportunities for its use, and it is now doing work which by hand labor would have been impossible."

BALLOON FLIGHT — "A remarkable balloon voyage was made in Germany a few weeks ago by Dr. A. Benson, during which the balloon reached a height of 31,496 feet, or nearly six miles. The balloon was equipped with various instruments for making observations, and much of interest was observed concerning atmospheric physics."

COAL — "Coal is now the great source of power. A ton of coal represents eight or ten thousand man power hours, and perhaps over one thousand horse power hours. It can be produced for so small a price that in the regions of its production it is the smallest element in the expense of power production."

MACHINE GUN USE — "At a recent meeting in London of the Maxim-Nordenfelt Guns and Ammunition Company the chairman, Admiral Sir Edmund Commerell, said their 0.303 Maxim gun had cut down a tree seventeen inches in diameter in one minute. . . This indicates that perhaps the machine gun could be used in felling forest trees in place of saws and axes. While the gun appears to be efficacious on seventeen inch trees, probably it would be stuck if directed against some of the larger trees, such as those of Washington, where a diameter of six feet is not uncommon."

A MODERN SYLLOGISM

MAJOR PREMISE:

Bell Telephone System serves the American Public.



MINOR PREMISE:

Bell Telephone Laboratories develop the facilities of the Bell System.



CONCLUSION:

Therefore, Bell Laboratories serve the American Public.



And that is the *raison d'être* of the Laboratories. For the Bell Telephone System, the Laboratories carry on research studies in all the sciences and development work in all the engineering arts that relate to electrical communication.

For the Western Electric Company, the manufacturing unit of the System, the Laboratories develop equipment, prepare specifications for its construction, and engage in various engineering activities.

For the Armed Forces of the United States, under contracts of the Western Electric, the Laboratories have undertaken more than a thousand development projects — many with spectacular effect upon our enemies.

BELL TELEPHONE LABORATORIES ***explore and invent, devise and perfect for our Armed Forces at war and for continued improvements and economies in telephone service.***



. . . into a Thousand Glorious Tomorrows

America is the land of dreamers and doers, where the tomorrows give promise and strength to those who dare to look ahead, work and have faith.

Pioneering, expanding and accepting that which was new and better, ROCK ISLAND LINES has served and grown . . . with America. We are proud of our 92 years of work and progress, through peace and war, prosperity and depression . . . always with faith in the future of America and its progressive people.

But yesterday is important only because it gave us courage to plan for our tomorrows. And ROCK ISLAND LINES has plans for tomorrow . . . interesting and ambitious.

All America is planning now. Dreamers and doers will be rewarded by many glorious tomorrows; a nation grown even greater with ever higher standards of life, comfort and happiness.

ROCK ISLAND LINES, against a backdrop of proud and glorious yesterdays, pledges that it shall take a hand in providing the bright future you are hoping for. All of us, planning and working together, dreaming and doing, will prove once more that America can make its dreams come true.

As yesterday — and today — so tomorrow ROCK ISLAND'S sole purpose is to provide the finest in transportation.

Rock Island

ROCK ISLAND LINES

ONE OF AMERICA'S RAILROADS — ALL UNITED FOR VICTORY

Scientific American
MARCH · 1945

* *100th Anniversary Year* *



"Old Ironsides" heads the first railroad train in Pennsylvania. First trip made November 23, 1832

On The Railroad Frontier

From the Wood-Burning Engines of a Century Ago to the Streamliners of Today, the Railroads have Served All Industry in Many Ways. Here is the Compact Story of Railroad Progress

By C. B. PECK

At the time they were first projected in America, railways had been in service in England for about 150 years. The simple wood rails had been replaced with various patterns of cast-iron rails and, in the decade after 1820, rolled wrought-iron rails were rapidly taking the lead.

The English track gage was 4 feet, 8½ inches. This gage prevailed on the early American railroads, although there were exceptions to it. A notable one was the New York & Erie Railroad, which was originally built from Piermont, New York, to Dunkirk, on Lake Erie, with a 6-foot gage. For many years the American railway system has standardized on the 4-foot, 8½-inch gage with the exception of a few isolated narrow-gage lines.

In the United States of the early 1800's there was a scarcity of iron, while timber was plentiful and cheap. Nicholas Wood, in his "Practical Treatise on Rail Roads" (London, 1838), described American track structure as consisting of wood rails, laid in parallel trenches filled with broken stone or gravel on white oak cross-ties, also laid in ballast-filled trenches. On the top of the wood rail was spiked an iron plate, cut diagonally at the ends. Other early tracks in the United States were laid with continuous granite sills, instead of the wood rails and cross-ties. The flat iron rails were attached to the tops of the stone sills. The wood track proved much faster and cheaper to build and so became the preferred construction despite its supposed inferior durability.

When Robert L. Stevens, president and chief engineer of the Camden & Amboy Railroad and Transportation Company, went to England in 1830 to buy the locomotive "John Bull," he whittled out a section of a rail which would not need chairs to support it. This section had an enlarged head and a wide flat base.

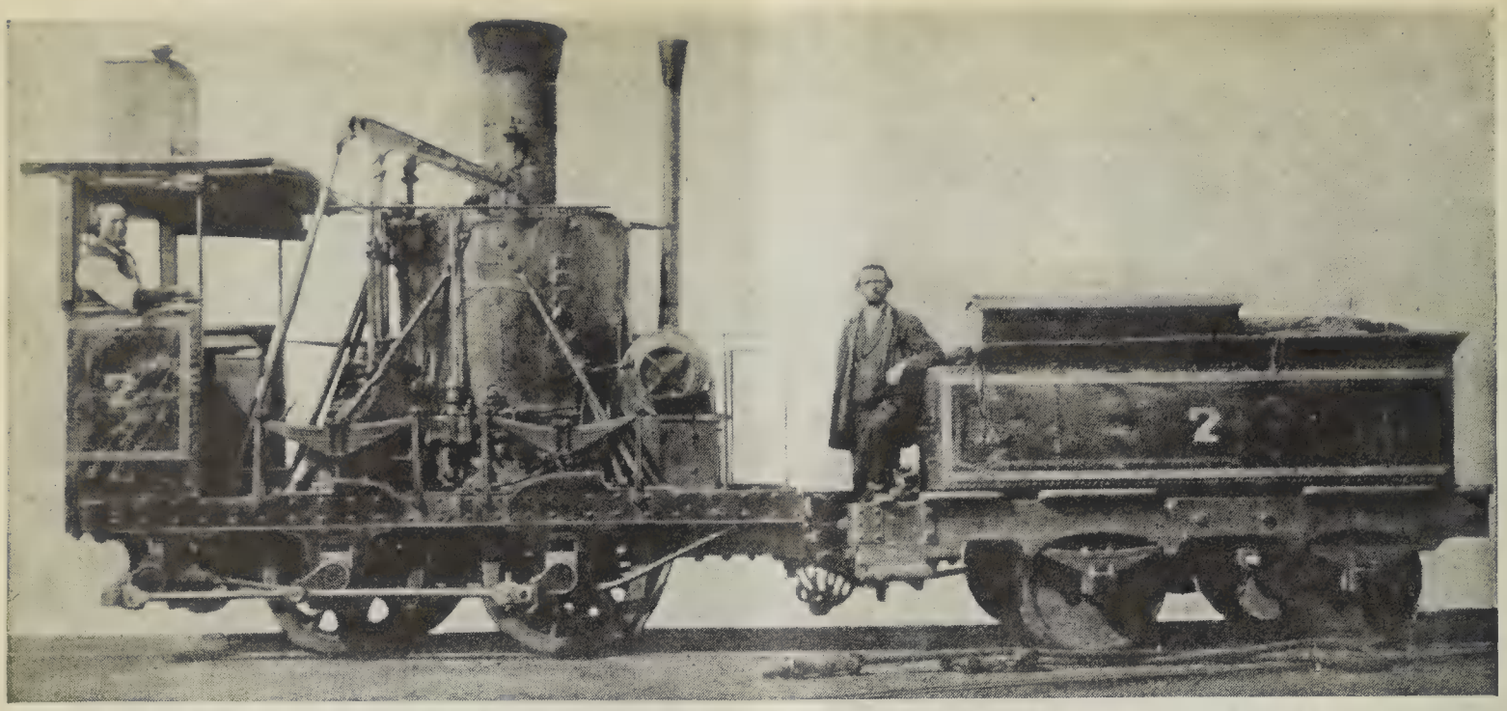
Because such iron rails were expensive and difficult to secure, the strap rail was widely used until the middle 1850's despite its unreliability in service. The spikes had a way of working out, particularly at the ends which, occasionally would be caught by a wheel and the rail peeled up in a "snakehead" which was driven through the car floor, placing the lives of the passengers in jeopardy.

The first iron rail to be rolled in America was the Evans U-section. It was rolled at Frostburg, Maryland, in 1844, and was laid on the Baltimore & Ohio Railroad.

In 1845 T-rails were first rolled in the United States at the Montour Rolling Mill, built at Danville, Pennsylvania to roll rails exclusively. Thereafter, facilities for producing wrought-iron rails multiplied rapidly.

STEEL RAILS—In 1865 the first steel rails were rolled in America at the Chicago Rolling Mill, since then a part of the property of the United States Steel Corporation. The first commercial order, rolled two years later, marked the beginning of the Bessemer era.

Steel rails continued to be rolled in the squat form characteristic of the wrought-iron rail for nearly half a century despite the fact that within 10 years this form was known



A member of the "Atlantic" family of locomotives on the B & O. It was originally built without cab

to lack adequate stiffness. A long period of tinkering with the section, without improving its fundamental weakness, began in 1874.

A notable exception to this course of events was the rail developed by Dr. P. H. Dudley of the New York Central & Hudson River Railroad in 1883. This had a high section with a relatively thin head and thick base, and weighed 80 pounds per yard. It demonstrated marked superiority over the customary sections, both as to stiffness and wear, but the prevailing engineering opinion of the period was too deeply entrenched to be changed at once.

It was not until 1933 that the need for stiffness was officially recognized by the American Railway Engineering Association. The 112-pound and 131-pound sections adopted in that year have since superseded all of the earlier sections for rail over 100 pounds per yard.

The 131-pound section is designed for axle loads of 80,000 pounds operating at speeds up to 80 miles per hour. Already the Pennsylvania Railroad has designed and is laying rail of high section weighing 152 pounds per yard for axle loads up to 100,000 pounds operating at 100 miles per hour.

Bessemer steel had demonstrated as early as 1900 its inability to stand up under increasing wheel loads and heavy traffic volume, and thereafter was rapidly superseded by open-hearth rail.

In 1911 arose the acute problem of transverse fissures—hidden deffects in the rail which resulted all too frequently in rail failures. After years of controversy between the railroads and the steel industry as to who was responsible, both groups finally pooled their interests and in 1931 began a joint investigation. Out of this came both a diagnosis and a successful remedy.*

Angle bars, bolts, tie plates, spikes, and rail anchors have all been changed by much the same kind of evolution as rail, both as to design and metallurgy. And what has happened to the cross-tie is even more spectacular. The white oak ties of the last century, if available today, would have a life of not over four to eight years. Today, the softer woods, after they have been creosoted or subjected to impregnation with other chemicals, are good for 20 to 25 years.

These developments have contributed to making present-day track highly stable as to line and surface and increasingly reliable as to its need for maintenance.

SIGNALING AND COMMUNICATION—The first 20 years of railway operation in America were without communications other than those provided by the trains themselves. As most of the railways were single tracked, the establishment of effective rules for the safe movement of trains, without undue delay to traffic, was a serious problem. One rule was that the "ruling train" had the right of one hour against opposing trains of the same class. A ruling train which had lost its hour was permitted, after waiting another 10 minutes, to proceed 20 minutes behind a flagman on foot, a tedious procedure limited in its scope by the endurance of the members of the crew.

In the fall of 1851 Charles Minot, superintendent of the New York & Erie Railroad, made the first use of the telegraph to issue orders for the movement of trains, saving an hour or more of delay which would have been incurred under the then current operating rules. The use of the telegraph to transmit train orders was thereafter regular practice on the Erie. Several years elapsed, however, before other railroads began to adopt it.

The semaphore signal was used very early on American railways. The early signals of this type were operated on a "time-interval" system. The signal was set at the "stop" indication for five minutes following the departure of a train and then cleared.

BLOCK SIGNALS—In 1863 Ashbel Welsh, general president and chief engineer of the New Jersey Canal & Railroad Companies (now part of the main line of the Pennsylvania Railroad), installed a system of block signals for controlling the movement of trains. Unlike the time-interval system, the purpose of this block system was to maintain a minimum space interval between trains moving in the same direction. The signal was an oil lamp set in front of a polished white reflector, enclosed in a box which normally concealed the light of the lamp. If, when a train approached, the section of line ahead (the "block") was clear, the lamp was lifted by means of a lever and rope, which was operated from within the station. In its upper position the light of the lamp by night or the white reflector by day showed through a glass window in the box. This was the "safety" aspect. When no light or the black interior of the box was displayed at a station, the train was required to stop. This signal was later improved by fixing the position of the lamp behind the window and drawing a red flannel curtain over the window when a train stop was required. The blocks are said not to have exceeded six miles in length.

Following the leasing of the New Jersey Canal & Railroad Companies' line by the Pennsylvania Railroad in 1871, this system of signals was extended to Pittsburgh. Before 1890 similar block signal systems were in operation on four more railroads: the West Shore, the Erie, the New York Central & Hudson River, and the Chicago, Burlington & Quincy. On parts of their lines the Erie and the New York Central & Hudson River installed a system of electrically controlled manual block signals in which electro-magnets automatically locked the signal lever against movement to the clear indication as long as the track ahead was occupied.

The early installations on all these roads were on double-track lines which were signaled for operation of each track in one direction. The first installation of block signals to a

*See Scientific American for January, 1944, page 17.

single-track line to receive prominent attention was on the Canadian Pacific in 1884.

The first installation of the automatic block signal system, which has since superseded the controlled manual system, was in 1871, when Thomas S. Hall signaled 16 miles of the Eastern Railroad (now part of the Boston & Maine Railroad). Hall employed a track instrument in the nature of a treadle which, depressed by passing wheels, closed an electric circuit in a wire carried on poles at the roadside.

TRACK CIRCUITS—This system, with its open roadside circuit, was soon superseded by the closed track circuit, comprising the two rails, one for each side of the circuit insulated in block-section lengths. The rails were connected to the two terminals of an electric battery at one end of the block section and to a relay at the opposite end. Normally, the relay was energized, but when a train entered the section at the relay end, the wheels and axles shunted out most of the current. This de-energized the relay and caused the signal to display the "stop" aspect until the train had passed out of that block. The closed-rail track circuit was developed by Dr. William Robinson and installed on the Philadelphia & Erie (now part of the Pennsylvania Railroad) at Kinzua, Pennsylvania, in 1872. It has since been recognized as the only safe means whereby a train may retain control of a signal while occupying the section of track protected by the signal. In 1877 the first signals controlled by more than one track circuit were installed by Dr. Robinson.

More recent developments in signaling are the replacement of the semaphore blades by lights which give the indications both day and night. There are color signals which have separate lights and lenses for each color indication, and others in which the color aspect of a single light and lens is changed by a movable spectacle within the case. And there are position lights, yellow in color, and arranged in rows of three to give angular position aspects similar to those of the semaphore blade.

Power for operation of track circuits and for moving the signal arms was long obtained from primary batteries. They are being superseded by purchased power. To reduce the power consumption, track circuits and relays are arranged for "approach lighting." This arrangement permits the signal lights to remain unlit until a train enters the block in front of the signal and to go out again as soon as the train has left the block beyond the signal.

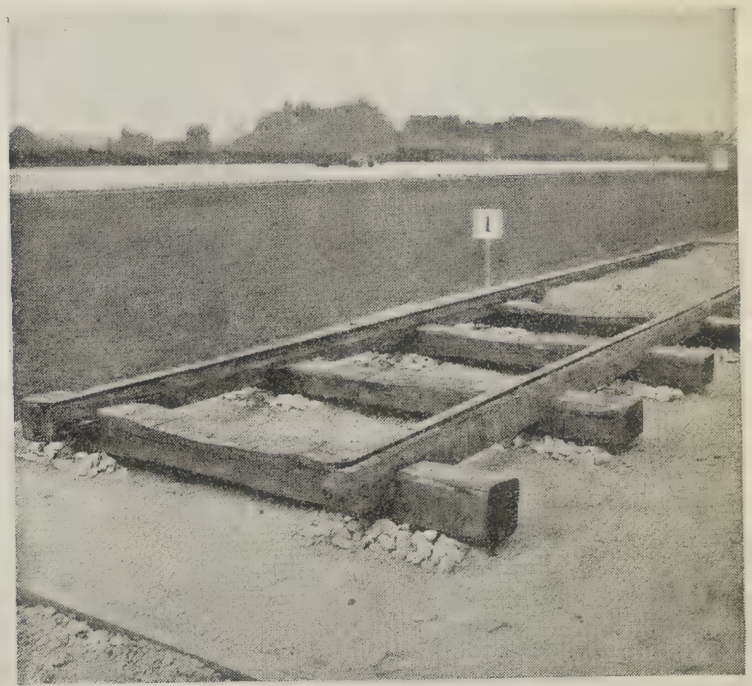
Each forward step in communications has increased the capacity of the line at the same time that it has made the movement of trains safer. The first major improvement supplemented the operation of trains by timetable and rules with the telegraphic train order. The block signal system, in turn, supplemented and simplified the application of train orders. Each step reduced the interference with train movement.

The first complete system for directing train movements over an operating division by signal indication without train orders was placed in service on the Missouri Pacific in 1925, using controlled manual block for controlling train movements. The CTC (centralized traffic control) system, was first installed on the New York Central in 1927. It places the signals and switches over a considerable territory under the remote control of an operator directed by the despatcher. No communications with the train are required other than signal indications.

AUTOMATIC CONTROL—Another development associated with signaling is automatic train control, the purpose of which is to insure safe operation in the event of a failure in alertness of the engineman. This involves a form of communication between the locomotive and roadway. The first system involved a track ramp contacting a shoe on the locomotive. Another system of the intermittent type operates inductively and involves no physical contact. The continuous system employs an alternating current passing through the rails which results in an electric field around each rail. Coils on the locomotive are affected by this field. In all of these devices, signal indications are translated into the action called for, which is put into effect automatically in case the engineman fails to do so.

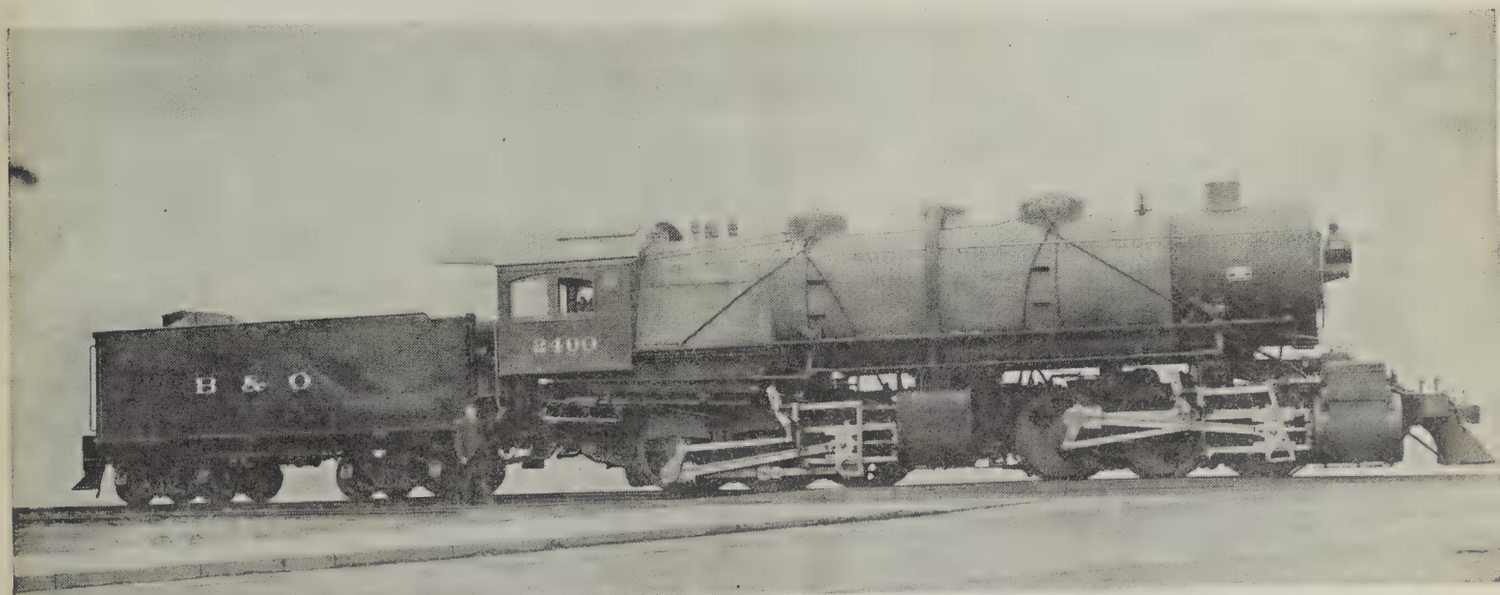
Accessory to the continuous train-control system is the continuously controlled cab-signal system. A substantial body of informed opinion considers the continuous cab signal more useful as a safety device than the train-control system itself.

The first interlocking plant in America was imported from England and installed on the line of the United New Jersey Canal & Railroad Companies at Trenton, New Jersey, in



Courtesy "Railway Age"

A section of the first B & O track built in 1829-30. Iron plates, cut diagonally, were spiked to wood rails



The first Mallet articulated compound locomotive in America. Built in 1904

1870. This comprised mechanical locking of manually operated switches and signals.

Two other systems have since largely superseded the mechanical system. Electric interlocking, in which the switches and signals are both operated by electric motors, was invented by John B. Taylor and the first installation in the United States was made in 1899. Electro-pneumatic interlocking is the invention of George Westinghouse. In this system the source of power for the movement of switches and signals is compressed air controlled by electrically operated solenoid valves.

THE STEAM LOCOMOTIVE—The track structures of the early American railway were much lighter than those in England and the curves were of shorter radii. The four locomotives ordered in England by Horatio Allen for the Delaware & Hudson Canal & Banking Company in 1828 were too heavy for the road and only one of them, the "Stourbridge Lion," was ever set up. It was the first locomotive to run on rails in America, but its trial demonstrated its impracticability.

The West Point Foundry in New York City had set up the Stourbridge Lion in 1829 and thereafter became a builder of locomotives. The "Best Friend," credited with being the first American-built locomotive to be placed in regular service, and another locomotive, were built in 1830 for the Charleston & Hamburg Railway. The "DeWitt Clinton," for the Hudson & Mohawk, was built a year later.

Peter Cooper's "Tom Thumb" contributed nothing to the technical development of the locomotive, but it encouraged the directors of the Baltimore & Ohio to continue their search for a suitable steam locomotive. The "York" (3½ tons) built by Davis & Gartner of York, Pennsylvania, met the terms of a prize contest and was followed by the "Atlantic" (6½ tons) and a whole series of "grasshoppers" with upright boilers and gear drives.

None of these locomotives was influenced by the results of the Rainhill Trials held by the Liverpool & Manchester in October, 1829. The first American locomotives to include the features which caused George Stephenson's "Rocket" to succeed in that famous event were built by Matthias Baldwin and William Norris in Philadelphia in 1832. Baldwin's "Old Ironsides" followed closely the characteristics of Stephenson's "Planet" class. Unlike the latter, however, it had outside cylinders and rods, instead of the inside cylinders driving on cranked axles favored by the British for their superior lateral stability.

Other locomotive builders established during the 1830's were Eastwick & Harrison, Philadelphia; The Locks & Canals Company of Lowell, Massachusetts; Rogers, Ketchum & Grosvenor of Paterson New Jersey; and Isaac Hinckley of Boston. The Paterson firm was a builder of textile machinery until Thomas Rogers, the active member, was induced to manufacture springs, wheels, and axles for the Charleston & Hamburg by Horatio Allen, its chief engineer. This preceded by several years the building of the "Sandusky" for the Mad River & Lake Erie in 1837.

ENGINE TYPES—Succeeding Phineas Davis of Davis & Gartner, Ross Winans became the leader in building locomotives for the Baltimore & Ohio. He is famous for two types. The "Mud Digger" had eight coupled wheels driven by gearing from a jack shaft. In 1850 he developed the "Camel" type, another eight-coupled locomotive noted for its unusual firebox for burning bituminous coal. Neither type has survived.

One of the most important of the early inventions for locomotives was the four-wheel swivel engine truck invented by John B. Jervis, another name made famous by its association with the Delaware & Hudson Canal & Banking Company, who was, in 1831, chief engineer of the Mohawk & Hudson. It adapted the locomotive to the weak track structure and sharp curves of America.

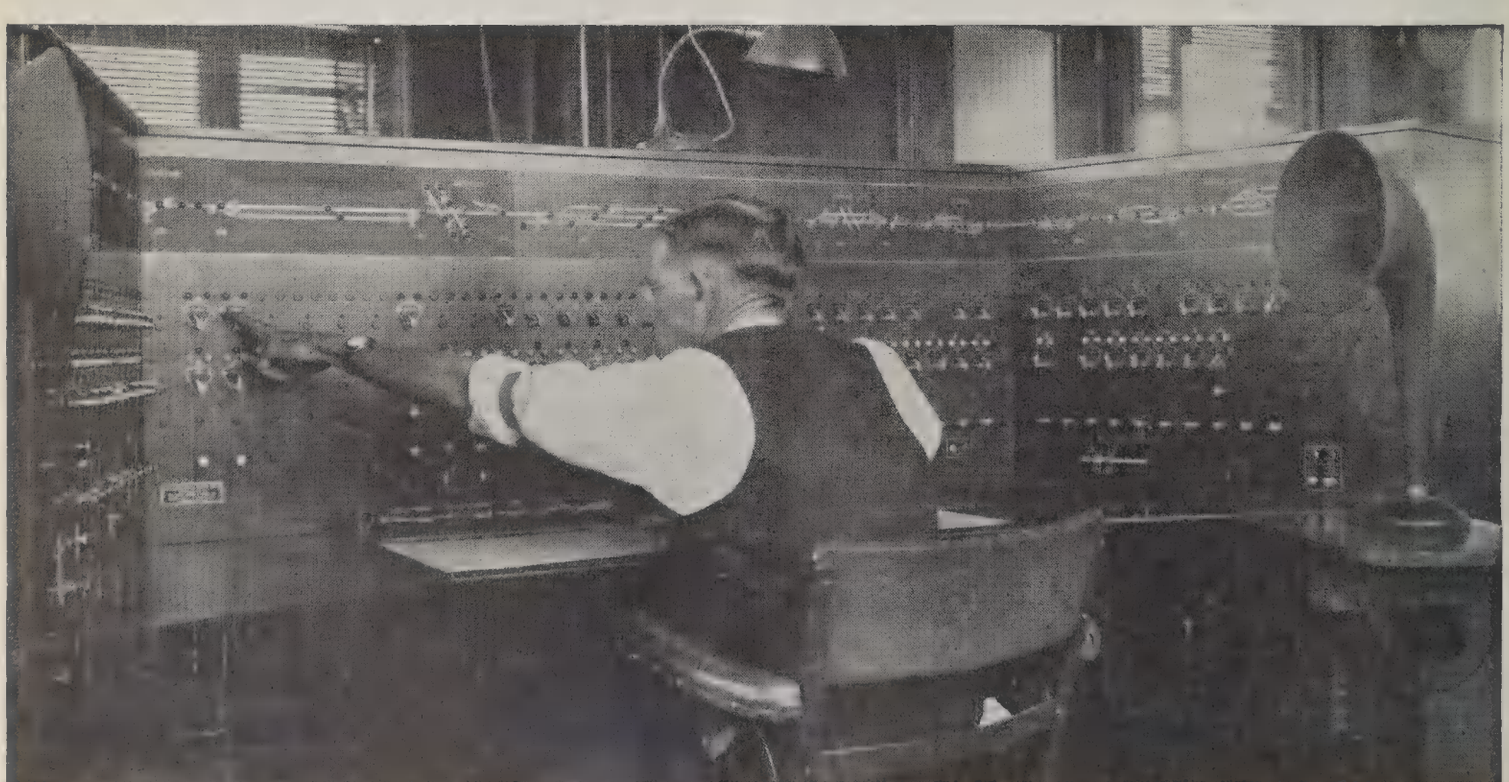
Henry R. Campbell, chief engineer of the Philadelphia, Germantown & Norristown, patented an eight-wheel locomotive with a four-wheel engine truck and four connected drivers and Eastwick & Harrison built such a locomotive in 1837. The driving axles were carried in an equalizing frame separate from the main locomotive frame; equalizing beams between the springs of the two axles were soon substituted for the separate frame construction. This method of adapting the locomotive wheels to the irregularities of track surface has since been a feature of American locomotive construction.

Matthias Baldwin invented the ground metallic steam-pipe joint by which he replaced the canvas and red-lead gaskets of the early British locomotives. This permitted him to boost steam pressures from 60 pounds per square inch to 120 pounds.

Thomas Rogers designed a driving-wheel center with a U-section rim. He is credited with the first effort at counterbalancing the weights on the crank pin of the Sandusky. He substituted the link valve motion for the prevailing hook motion in 1839.

By 1855 more than 40 separate plants were engaged in building locomotives. The major characteristics of American practice were so well established that from that time on there was less difference in the products of the various plants than there were between successive locomotives of the same builder during the 1830's and early 40's.

Since 1860 a great variety of wheel arrangements has been developed and there has been a steady increase in locomotive weights and capacities. At the outset the trend was toward



By control of track switches and signal indications, the operator controls train movements without train orders

more tractive capacity at slow speeds and relatively little attention was paid to the development of sustained high tractive force at high speeds. Following World War I, the demand for faster movement without sacrificing weight of train changed the trend toward increased horsepower capacity. This has led to four- and, in a few cases, six-wheel trailer trucks to carry the additional boiler weight required.

The use of double-expansion cylinders was inaugurated in 1889. By 1900 compounding had reached its peak and rapidly receded. The economy effected was largely a reduction in condensation losses. With the advent of the superheater, condensation losses were practically eliminated in single-expansion cylinders.

SUPERHEAT—The practical development of the locomotive superheater in America began when the Locomotive Superheater Company was organized in 1910. It acquired several American and foreign patents and proceeded with the engineering development of the fire-tube superheater. A high percentage of all steam road locomotives are now equipped with superheaters which effect economies in fuel consumption of about 25 percent and reduce water consumption by about 30 percent.

A closed-type feedwater heater, the feature of which is a high rate of heat transfer, was patented by Luther B. Lovekin and made available for service in 1916. Two years later an open-type feedwater heater was adapted from a marine heater by T. C. McBride. These have subsequently been supplemented by the exhaust-steam injector and few road locomotives in through service are now without some form of feedwater heating. From 10 to 13 percent of the heat in the fuel is reclaimed by the feedwater heater. About 12 percent of the exhaust steam which is condensed by the heater passes into the tank or boiler and increases the effective capacity of the tender.

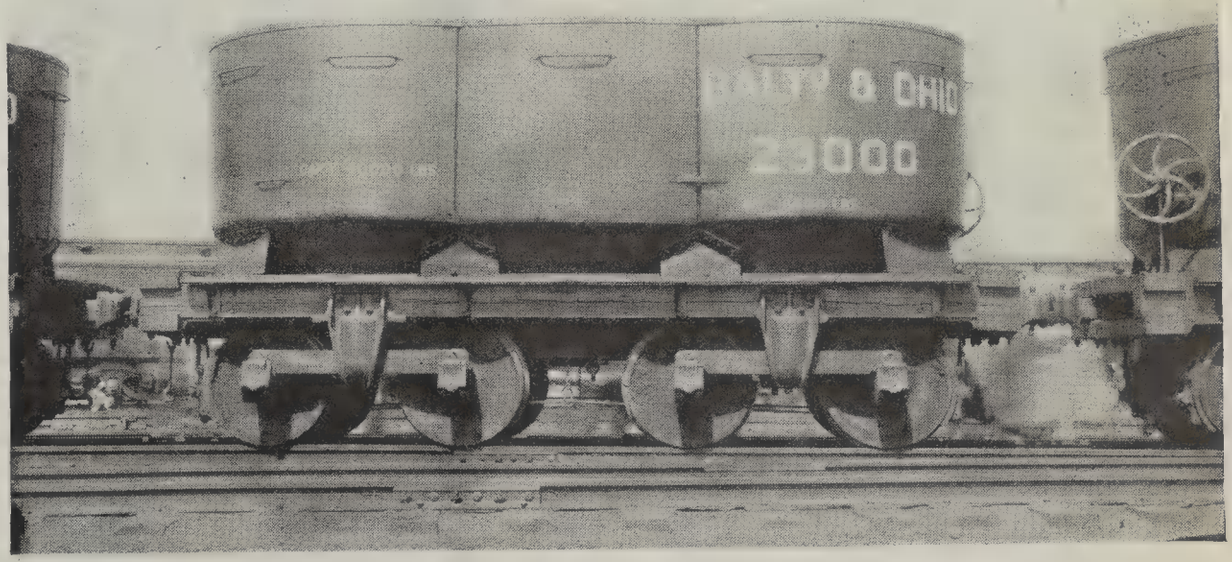
With the development of the wide firebox and increasing grate areas the fireman began to limit the capacity of the steam locomotive about 1900. Grates much in excess of 45 to 50 square feet in area were beyond the capacity of a single fireman. In 1909 an overfeed stoker was developed by Clement F. Street, and several other stokers came out at about that time. The Standard stoker, the type which is most widely used at present, was first installed in 1913.

Stokers have been applied on locomotives with over 180 square feet of grate area which are capable of delivering coal to the firebox at the rate of 20 tons an hour.

In 1918 an appliance known as the Nicholson Thermic Syphon was first installed in the firebox of a Chicago, Milwaukee & St. Paul locomotive. This device replaces the arch tubes by which the sectional brick arch is supported and provides a thin triangular water space which opens through a long slot in the crown sheet (the sheet directly over the fire) and tapers down to a pipe-like connection to the throat sheet (front firebox sheet immediately below the boiler barrel) just above the grate. This device stimulates a rapid backward circulation along the bottom of the boiler shell. It is credited with an increase in evaporation and has proved effective in preventing dangerous overheating of crown sheets under some low-water conditions.

A circulator, several of which are placed transversely in the firebox, has since been developed for somewhat the same purpose. This device draws its water through the side sheets of the firebox and delivers water and steam through an opening in the center of the crown sheet.

In 1918 an auxiliary steam engine was applied to the trailer of a Pacific type locomotive on the New York Central to increase traction at starting and slow speeds. This device, known as the Locomotive Booster, was patented by Howard L. Ingersoll, assistant to the president of the railroad. It drives the trailer axle and its controls are interlocked with the locomotive throttle.



A three-hopper iron coal car equipped with Winan's four-wheel trucks. Iron cars of two intersecting cylinders were first built for the B & O about 1860

Large steel castings are characteristics of the modern steam locomotive. First was the water-bottom tender frame which comprises the entire tender underframe and the bottom of the water tank, to which the outside tank sheets are attached either by riveting or welding. This was followed by the locomotive bed casting which incorporates in a single piece of cast steel the entire frame system of the locomotive from the front bumper to the rear end, including the steam chests, cylinders, and saddle on which the smokebox is supported. Harry M. Pflager, senior vice-president of the General Steel Castings Corporation, is credited with the development of these large and intricate castings.

LUBRICATION—One of the great changes which has taken place in the steam locomotive during the last 25 years is the replacement of the long-spout oil can as a source of lubrication for most of the running gear and motion work. Today, the entire chassis is provided either with force-feed oil lubrication, hard-grease lubrication, or Alemite lubrication, which will permit the locomotive to run between terminals without attention.

A factor in increasing the utilization of the steam locomotive and permitting relatively long runs without stops is the large tender. Twenty-five years ago few tenders were built with water capacities of more than 10,000 gallons and coal capacities of more than 15 tons. Today, locomotives are running with 25,000 gallons of water and 30 tons of coal. On one railroad where water is scooped en route the coal pit has a capacity of 43 tons.

ELECTRIFICATION—The principal factors impelling the installation of heavy electric traction are: (1) Special operating conditions, such as may be encountered on heavy grades, in tunnels, and in densely populated districts where smoke and gases from steam locomotives are a serious nuisance; (2) the need for more intensive road facilities where the saturation point is being reached on densely trafficked lines

under steam operation and (3), associated with the other two, considerations of operating economy.

The first heavy electric traction was used to operate trains through tunnels without the handicap of combustion gases from steam locomotives. Such applications were in the Mt. Royal tunnel of the Baltimore & Ohio (1895), the St. Clair tunnel of the Grand Trunk (now the Canadian National) (1908), and the Hoosic tunnel of the Boston & Maine (1911). Later applications included the Michigan Central tunnel under the Detroit River and that of the Canadian National under Mount Royal at Montreal, Quebec.

The electrification of the New York Central in connection with the Grand Central Terminal development went into service in 1906 and that of the New York, New Haven & Hartford a year later.

The Pennsylvania New York terminal development and the Long Island followed in 1910. Various mileages have since been electrified on the Butte, Anaconda & Pacific; the Chicago, Milwaukee, St. Paul & Pacific; the Norfolk & Western; the Virginian; the Staten Island lines of the Baltimore & Ohio; the Illinois Central; the Great Northern; the Reading; the Delaware, Lackawanna & Western; and the New York Central West Side lines in New York City. With the completion of the Pennsylvania electrification from New York to Washington, D. C., and Harrisburg, Pennsylvania, route mileage of electrified line now totals about 2300.

INTERNAL COMBUSTION—In 1899 a gasoline-engine-driven coach was placed in trial service on the Pennsylvania Railroad and the Cleveland, Cincinnati, Chicago & St. Louis Railway by the Jewett Car Company, Jewett, Ohio. In 1904 the McKeen mechanical-transmission car was brought out and in 1905 a gas-electric system was developed by the General Electric Company. These engines operated at relatively slow crank-shaft speed and the engines and electric generators were heavy.

In 1921 began an attempt to adapt the motor-truck chassis and engine with a gear-shift transmission for rail operation by fitting it with a light coach body. This was soon outgrown by the demand for larger and more powerful cars. By 1928 most of the cars built weighed from 100,000 to 150,000 pounds, with power plants ranging from 250 to over 400 horsepower.

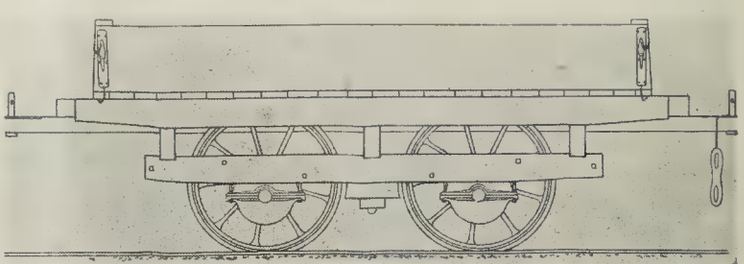
In 1924 a Diesel-electric locomotive developing 300 horsepower and weighing 60 tons was built by Ingersoll-Rand and General Electric. This locomotive demonstrated the practicability of a low-capacity power plant, the entire horsepower of which, via the electric transmission, can be developed at any speed of the locomotive for switching service. The first locomotive of this type entered regular service in 1925 on the Central Railroad of New Jersey.

In 1928 a two-unit 2660 horsepower Diesel-electric locomotive was built for the Canadian National by the Westinghouse Electric & Manufacturing Company. This locomotive was designed for determining the utility of the Diesel in road service.

The next important step in the adaptation of internal-combustion power plants to railroad traction purposes came with the development of streamlined light-weight articulated trains. Except for the first aluminum-alloy train for the Union Pacific, all these early trains, built for that railway and the Chicago, Burlington & Quincy during and subsequent to 1934, were driven by Electro-Motive Diesel-electric power plants. At the outset these were installed at the front end of the head revenue car. But the length and size of the power plant of each successive train increased and it was not long before the power plant and auxiliary equipment fully occupied first one, then two, and finally three vehicles. Thus, the rail-motor-car power plant evolved into a full-fledged passenger locomotive.

In 1941 the Electro-Motive Division of the General Motors Corporation built a four-cab 5400 horsepower freight locomotive for the Atchison, Topeka & Santa Fe Railway. These locomotives have since been installed on several other railroads.

FREIGHT CARS—Ross Winans' first interest in railroads was as a market for horses. When he came to Baltimore in 1828, railway cars were carried on two axles, without springs, and the wheels still turned loosely on the axles. He interested himself in improving rolling stock to increase the hauling capacity of the horse. His first invention, in 1828,



An early B & O four-wheel freight car

was to fix the wheels on the axle and to put bearings on the ends of the axle outside the wheels. By 1834 he had developed a freight car carried on two four-wheel trucks. It was not adopted rapidly; four-wheel cars were still being built in the 1880's.

By 1832 the need of springs was apparent. The chief engineer of the Baltimore & Ohio wrote in his report of that year that "springs would be viewed as an indispensable appendage to all cars when steam shall be the power used in transit."

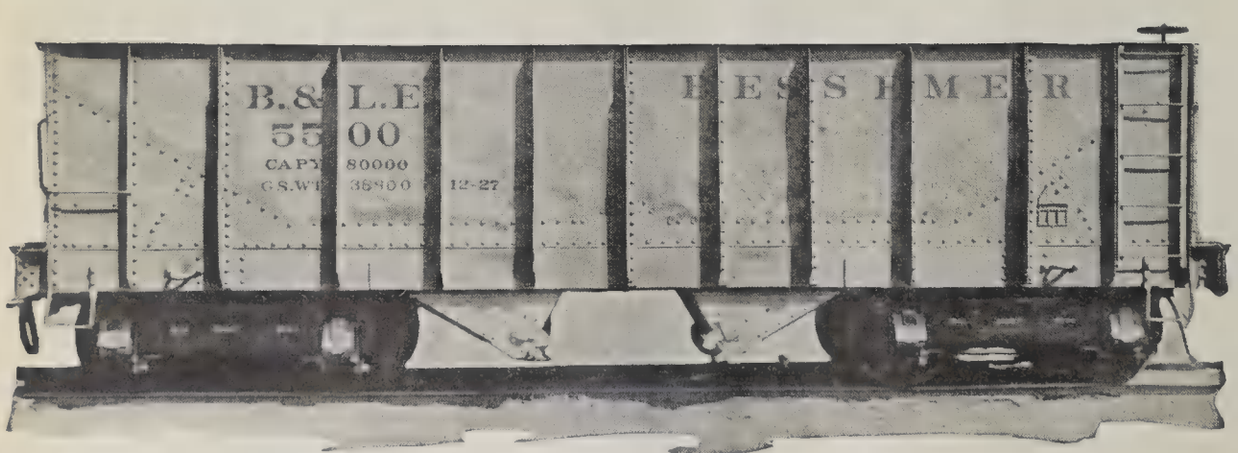
Iron was used very early in the construction of car bodies. The Philadelphia & Reading ordered 1000 new iron coal cars to be delivered in 1846. Iron hopper cars, gondola cars, and box cars were being built for the Baltimore & Ohio in the early 1860's.

In 1857 an eastern railroad is said to have had 30 box cars fitted with double sides, roofs, and floors, with the intervening spaces packed with sawdust. This, so far as is known, was the first step in the evolution of the refrigerator car.

After 1900 steel rapidly superseded wood as the principal material of construction both of freight and passenger cars. Six flat cars were built by the Carnegie Steel Company in 1894. Two years later the Keystone Bridge Company built two steel hopper cars of 100,000 pounds capacity each. These were placed in service on the Pittsburgh, Bessemer & Lake Erie, now the Bessemer & Lake Erie.

During the past 25 years the wood cars of relatively weak construction have gradually disappeared and the railways entered World War II with an inventory of freight cars of adequate and relatively uniform strength.

The use of high-tensile steels and light-weight metals as the materials of construction both for freight and pas-

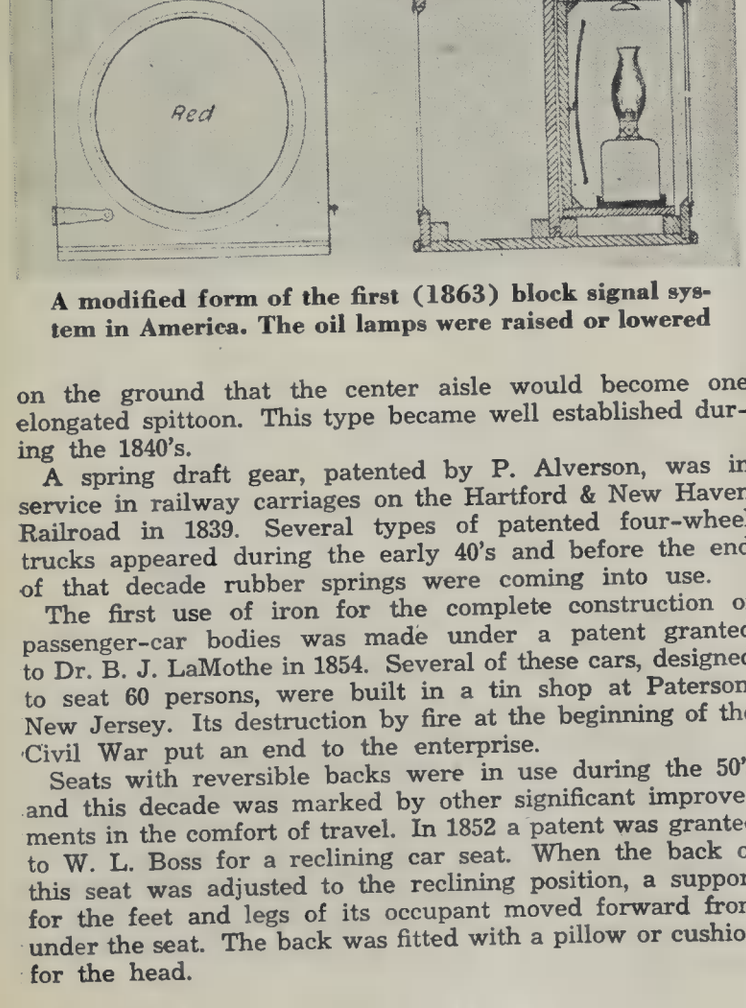


The first steel hopper car, built in 1896, from a photograph taken in 1928

senger cars began in 1934. The materials used are stainless steel, low-alloy high-tensile steels, and strong alloys of aluminum. Both the stainless and high-tensile steels possess high-tensile qualities and resistance to corrosion which permit the development of sufficient strength with lighter metal sections. The saving of weight in the aluminum construction results from the light weight of the metal which is used in relatively bulky sections.

In 1934 and 1935, the Baltimore & Ohio Railroad built one experimental hopper car of stainless steel, one of aluminum alloy, and several of low-alloy high-tensile steel. Since then, some 50,000 freight cars of various types have been built of the low-alloy high-tensile steel. A few additional cars of aluminum alloy have also been built. So far, however, stainless steel has been too expensive to be attractive for freight-car construction.

PASSENGER CARS—Probably the most comfortable of the early coaches were those in which the old Concord stage bodies were adapted to the rail by the use of flanged wheels. Others were simple boxes, some of them mounted on the axles without springs and with the simplest of benches for the accommodation of passengers. Coaches built with platforms and end doors, some with essentially the same seating arrangement that has since become universal in American practice, were adopted at an early date by the Baltimore & Ohio, not, however, without strong opposition



A modified form of the first (1863) block signal system in America. The oil lamps were raised or lowered

on the ground that the center aisle would become one elongated spittoon. This type became well established during the 1840's.

A spring draft gear, patented by P. Alverson, was in service in railway carriages on the Hartford & New Haven Railroad in 1839. Several types of patented four-wheel trucks appeared during the early 40's and before the end of that decade rubber springs were coming into use.

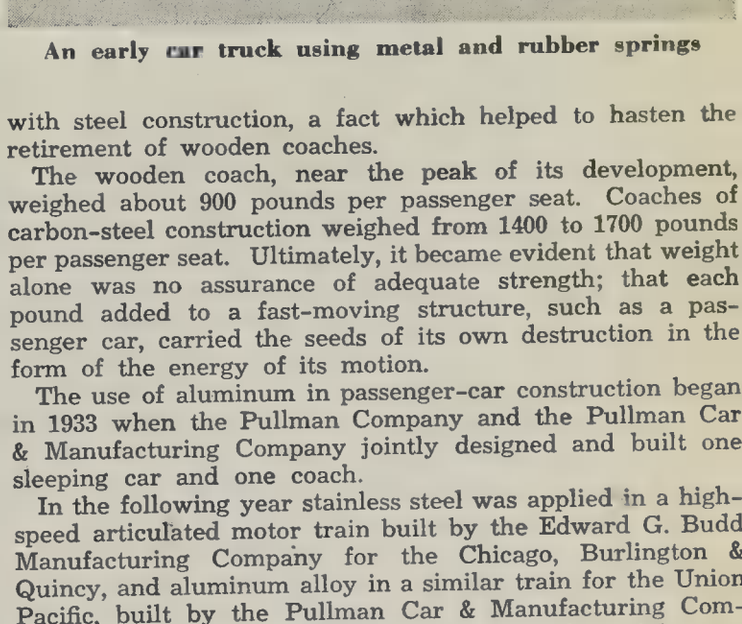
The first use of iron for the complete construction of passenger-car bodies was made under a patent granted to Dr. B. J. LaMothe in 1854. Several of these cars, designed to seat 60 persons, were built in a tin shop at Paterson, New Jersey. Its destruction by fire at the beginning of the Civil War put an end to the enterprise.

Seats with reversible backs were in use during the 50's and this decade was marked by other significant improvements in the comfort of travel. In 1852 a patent was granted to W. L. Boss for a reclining car seat. When the back of this seat was adjusted to the reclining position, a support for the feet and legs of its occupant moved forward from under the seat. The back was fitted with a pillow or cushion for the head.

Sleeping-car service of a kind is said to have been inaugurated on the Cumberland Valley Railroad between Harrisburg and Chambersburg in 1836. Seven years later, on the New York & Erie, cars with seats placed back to back were in service in which berths could be made up at night by the use of the seat cushions.

In 1858 George M. Pullman refitted two coaches for the Chicago & Alton with sleeping-car sections, a linen locker, and two washrooms. Following the incorporation of the Pullman Palace Car Company in 1867, the first "hotel car" was placed in service on the Great Western of Canada, now the Canadian National, and the development of dining-car service had begun.

STEEL FOR SAFETY—The railroads which first purchased steel coaches, shortly after 1900, made much of the increased safety afforded by this type of construction, because of its increased strength and stiffness in case of derailments or other accidents. The public thus came to associate safety



An early car truck using metal and rubber springs

with steel construction, a fact which helped to hasten the retirement of wooden coaches.

The wooden coach, near the peak of its development, weighed about 900 pounds per passenger seat. Coaches of carbon-steel construction weighed from 1400 to 1700 pounds per passenger seat. Ultimately, it became evident that weight alone was no assurance of adequate strength; that each pound added to a fast-moving structure, such as a passenger car, carried the seeds of its own destruction in the form of the energy of its motion.

The use of aluminum in passenger-car construction began in 1933 when the Pullman Company and the Pullman Car & Manufacturing Company jointly designed and built one sleeping car and one coach.

In the following year stainless steel was applied in a high-speed articulated motor train built by the Edward G. Budd Manufacturing Company for the Chicago, Burlington & Quincy, and aluminum alloy in a similar train for the Union Pacific, built by the Pullman Car & Manufacturing Company. Since that time a large number of light-weight passenger cars have been built in many of which the low-alloy high-tensile steels have been employed as the material of construction. Weight reductions approximate one third.

AIR BRAKES—George Westinghouse's first patent covered a straight-air brake system. This was issued in 1869. He was granted a patent on an automatic system in 1872. It took 15 years for the superiority of the automatic air brake to be clearly established.

The system of differential pressure control of compressed air invented by Mr. Westinghouse has proved to be a remarkably flexible medium. As cars increased in weight, and trains in length and speed, shocks caused by the running in and out of slack between cars became progressively more severe. Successive adaptations of the original operating principle have kept the brake abreast of the needs of the times in this respect.

The next step in freight brakes will be the load-compensating brake by which the present inequalities of retarding force in relation to gross car weight will be ironed out. This is ready to meet the needs of faster freight trains of light-weight cars.

Likewise, until the H.S.C. (high-speed control) passenger brake was brought out to meet the needs of the streamlined trains for operation on schedules calling for running at to

speeds over 100 miles an hour, the all-pneumatic brake met the requirements. Because of the value of split seconds in stopping these fast trains, the new passenger brake incorporates electric control of application and release.

COUPLERS AND DRAFT GEARS—Among the developments which have been of great significance in keeping rolling stock in step with the constantly growing needs of the service are automatic couplers and draft gears. The first standard form of coupler was the link and pin type which prevailed for many years. Because of the appalling number of casualties among trainmen from accidents in coupling cars, the Master Car Builders' Association took up the problem of developing some form of interchangeable coupler. As a result, the Janney vertical plane type of coupler was developed in 1887 as the standard form for freight cars.

Prior to this, the Miller hook type of coupler, more recently in use on street cars, had been introduced and was used extensively on railway passenger cars. The Janney type rapidly superseded it in passenger service. At first standardized for interchangeability of cars alone, it has since been subjected to a vast amount of development work resulting in a complete standardization of details revised from time to time to meet the changing conditions of service.

The draft gear, by which the buffing and pulling shocks on railway rolling stock are cushioned, long consisted of coil springs. The first patent for a friction draft gear in which the coil spring is supplemented by friction elements to dissipate a considerable portion of the energy taken up by the gear was issued to George Westinghouse in October, 1888. An early service installation of the Westinghouse device was made on Pennsylvania Railroad rolling stock in 1896. It was not until after the turn of the century, however, that the friction gear began to make headway.

Since 1934 all draft gears, before they may be offered in interchange, must have been certified by the Association of American Railroads as meeting specifications of limiting draft-gear characteristics worked out by the Association. This has brought uniformity of performance out of what for many years was an extremely chaotic situation.

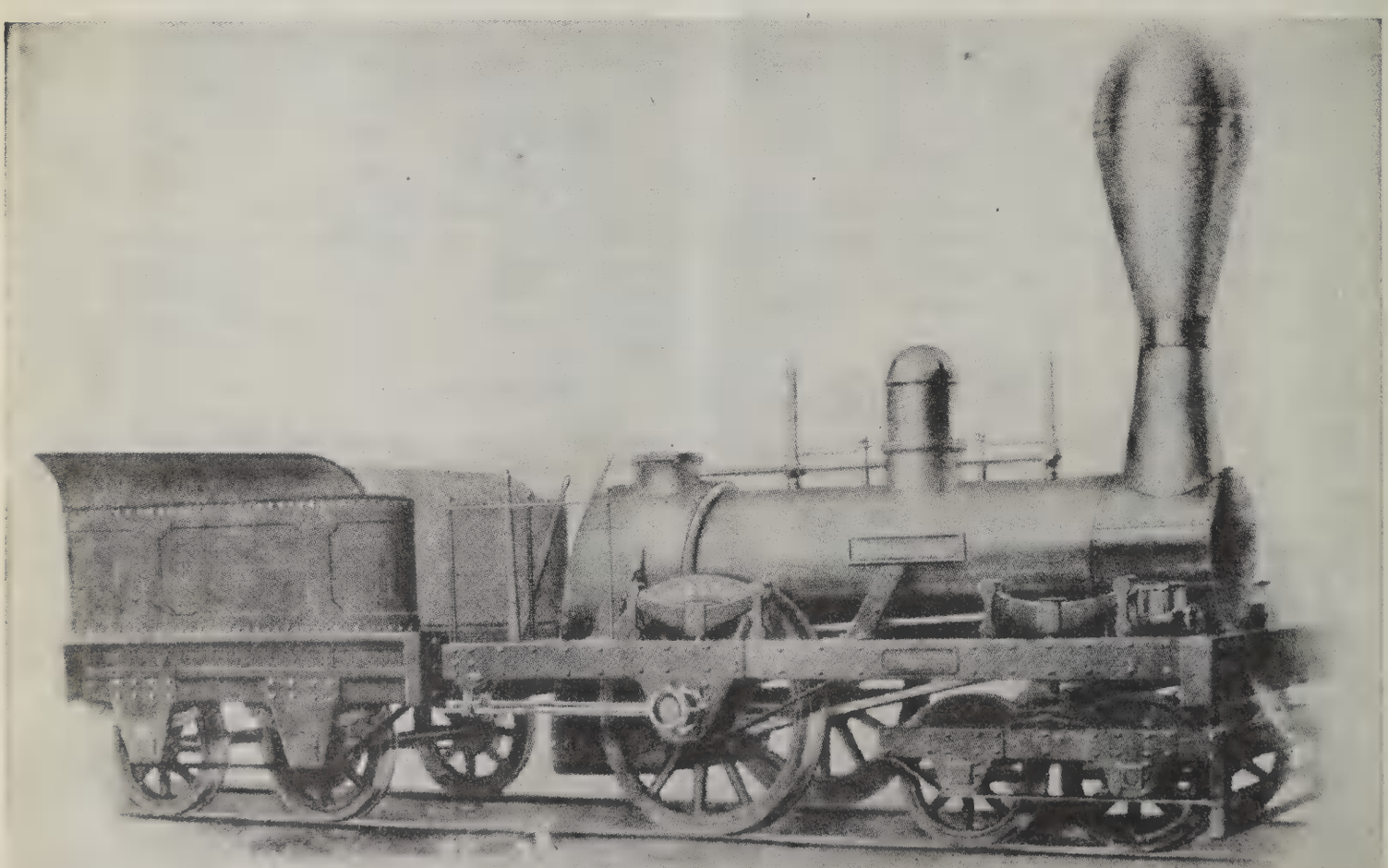
ROLLER BEARINGS—Development work on the adaptation of roller bearings to the passenger-car truck began on the Chicago, Milwaukee, St. Paul & Pacific in 1924 and was participated in by Hyatt Roller Bearing Company, SKF Industries, Inc., and Timken Roller Bearing Company. This railroad made its first installation in 1927 and the use of roller bearings on passenger cars developed rapidly thereafter.



Diesel-electric switching locomotive, 1925

Most of the road steam locomotives built in recent years have been fitted with roller bearings on all axle journals—a factor in increasing reliability and reducing machinery maintenance on steam locomotives. Acceptance of roller bearings on driving axle journals was hastened by a demonstration locomotive placed at the service of the railroads by Timken Roller Bearing Company in 1930.

HEATING AND LIGHTING—The evolution of car heating and lighting has tremendously improved the comfort and safety of railway travel. By the early 80's the entire railway world had become aroused to the need of a safer method of heating passenger cars than by stoves. When wrecks occurred, fire from the stoves caused much loss of life which otherwise would have been avoided. The heat distribution was also extremely unsatisfactory. Many schemes for improving both comfort and safety were being tried, among them the

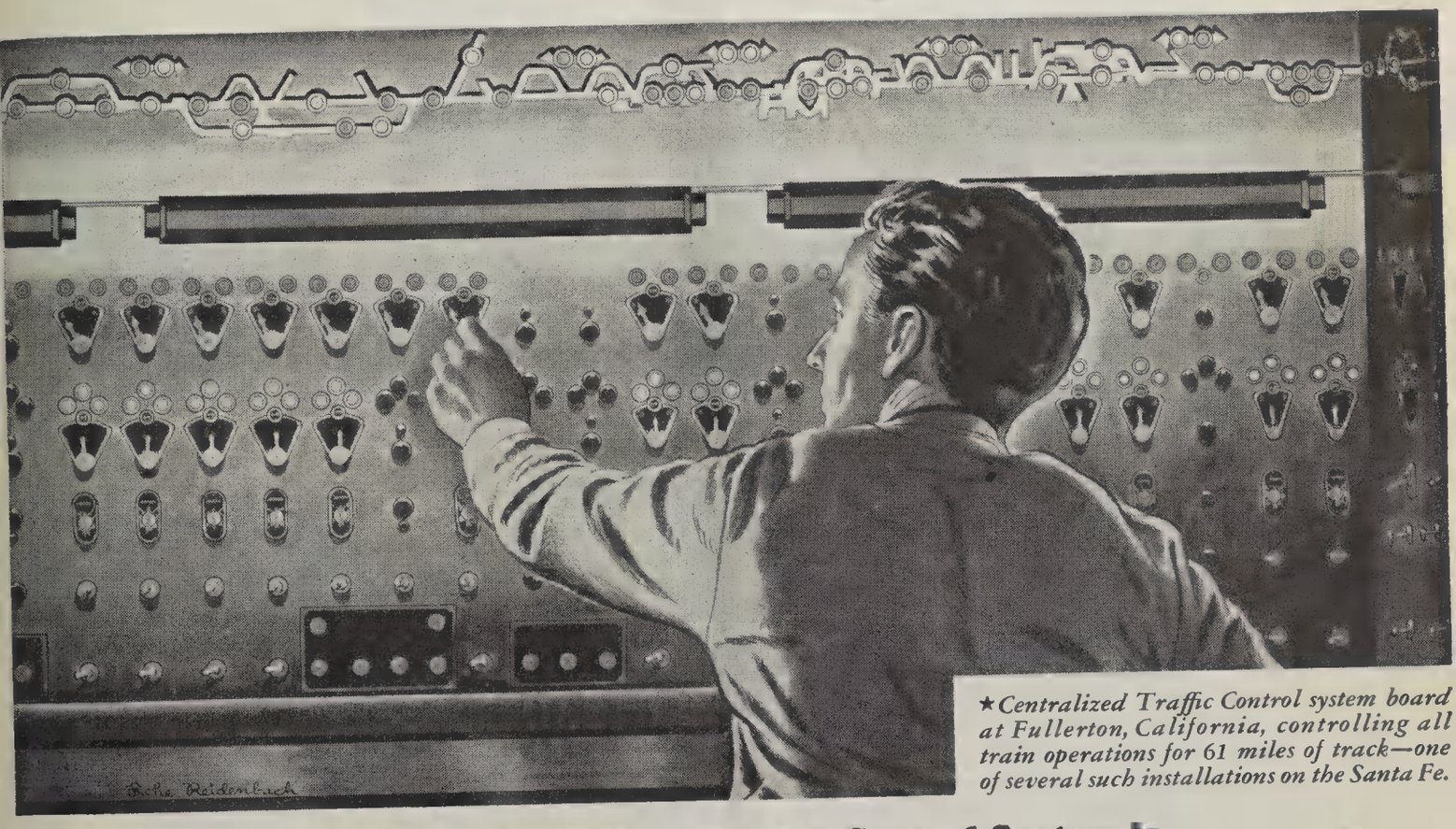


Rogers' Sandusky, 1837, from a model

(Another chapter in the story, "Working for Victory on the Santa Fe")

It's done with lights





★*Centralized Traffic Control system board at Fullerton, California, controlling all train operations for 61 miles of track—one of several such installations on the Santa Fe.*

How the Centralized Traffic Control System is speeding shipments to Pacific ports along the Santa Fe

You've seen a miniature railroad controlled by a central board.

Here you see how traffic is controlled on an important stretch of Santa Fe track in almost the same fashion.

On Santa Fe's big Centralized Traffic Control boards, miles of track are laid out in miniature scale before the eyes of the operator. Lights show the location of each train.

By simply turning a lever, the operator can signal an engineer miles away to take his train into a siding to clear the track for a train coming from the opposite direction.

It eliminates the issuing of train orders, cuts down the detention of needed freight cars, and conserves manpower and engine power.

It permits a greater use of track and switching facilities, virtually adding another "mainline" to important parts of the Santa Fe System.

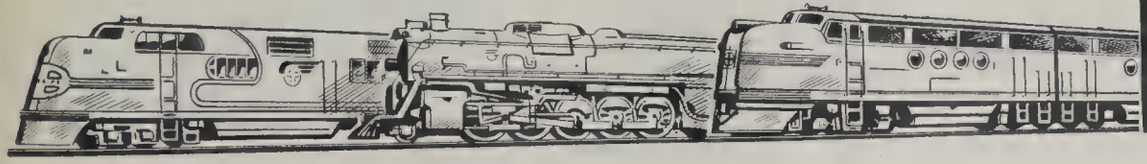
This efficient "C. T. C." system is just one more step Santa Fe is taking to move *more* vital war freight *faster.*

SANTA FE SYSTEM LINES

Serving the Southwest and California

ONE OF AMERICA'S RAILROADS—ALL UNITED FOR VICTORY

Santa Fe



use of steam from the locomotive. By 1890 this method was clearly in the ascendancy. The development of the modern vapor system removed the final hazard from car heating, which arose from the use of steam under pressure within the cars.

Air conditioning was first installed in a railway passenger-train car by the Pullman Company. An ice-cooled sleeping car began regular operation between Chicago and Los Angeles in September, 1929. This was followed in 1930 by installations in two dining cars, one each on the Baltimore & Ohio and the Atchison, Topeka & Santa Fe. The popularity of these cars was immediate and the spread of air conditioning was rapid.

The change in ventilation associated with the summer cooling aspect of air conditioning has done more to enhance the attractiveness of railway travel than the cooling itself. The universally used suction ventilation system drew great quantities of dust into the car around doors and windows. With the air-conditioning system, the direction of flow is reversed. The outward flow of the air thus seals all openings against the entrance of outdoor dirt.

The systems have also improved the quality of coach heating. Part of the heat is now transferred to the incoming air before it enters the coach space and the regulation of the combination of floor heat and overhead heat by thermostatic control makes possible a much improved adjustment to the needs of varying weather conditions.

The invention of the Pintsch gas lamp in 1867 led to the first major improvement in car lighting. Oil was superseded by gas during the 70's, but the gas held its place unchallenged for only a few years. In the early 80's began experiments with the application of electricity to car lighting, first with storage batteries and then with head-end power units. The Pennsylvania, the Chicago, Milwaukee & St. Paul, and the Baltimore & Ohio were the pioneers in this development. The power required by the carbon-filament lamps, however, was too great to make the system attractive until after 1900, when improvements in the incandescent lamp reduced the demand on batteries and generators, bringing the weight of equipment within practicable limits. From then on the axle-driven generator system come into general use.

Recent improvements in car lighting, notably the application of fluorescent lamps, have added still further to efficiency. But the addition of other power-using facilities, the largest of which is air conditioning, has stepped up the total auxiliary power demand on the modern de luxe passenger car. Where four-kilowatt lighting generators once were adequate, 20 kilowatt generators are now in use. Some of these are driven from the car axle. Others are being driven independently by propane-gas engines mounted underneath the cars.

THE OUTLOOK—The physical plant of the railroad has by no means attained its ultimate form. Among the changes in track now under trial are welded rails extending several thousand feet without a joint. Further modifications of rail section are also under consideration.

To supplement roadside telephone, telegraph, and signals, wireless communication between the head and rear end of moving trains and between the moving train and the roadside is under development.

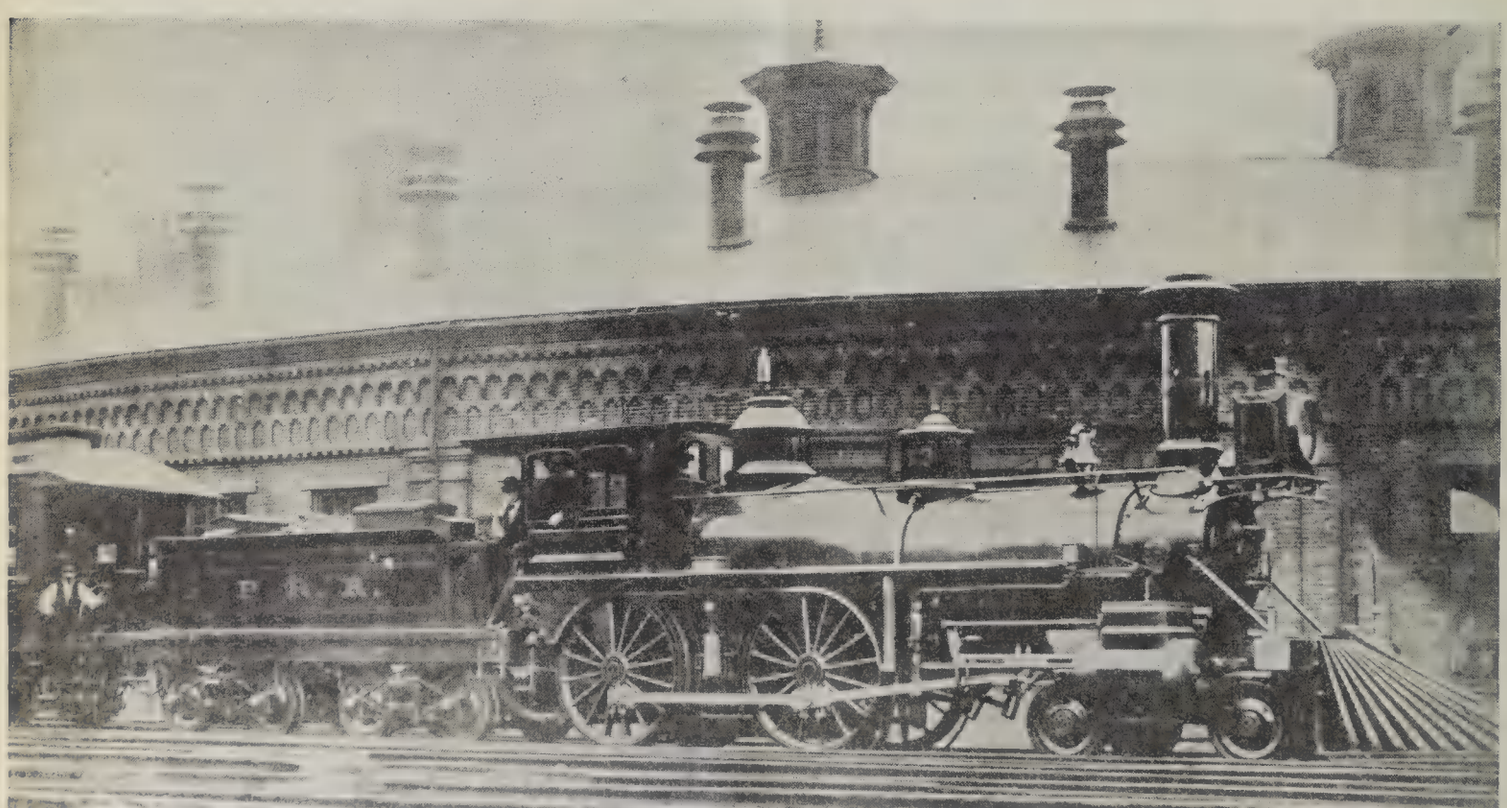
New types of motive power, under discussion for some time, include the steam turbine locomotive, one of which has been built for the Pennsylvania Railroad, and the gas-turbine locomotive. The early trials of poppet valves promise significant improvement in capacity and steam economy of conventional steam locomotives. More than one railroad is anxiously awaiting the opportunity to build all-welded locomotive boilers as soon as war-time restrictions will permit. Roller bearings on the crank pins and in the crossheads of steam locomotives have made a good start. War-time metallurgical advances promise new materials for locomotive boilers, as well as for forged parts.

The car truck, both passenger and freight, is in for a considerable overhauling in the interests of better riding at higher speeds. In passenger service the tightlock coupler is gaining ground and may, in time, replace the present free vertical plane type.



Railway Age photograph

In 1860 the first railway mail car was placed in service



Compressed air brakes for regular service were first installed by George Westinghouse on this locomotive

Weather-Proof Revolution

Our Armed Forces Needed Containers That Could Withstand Immersion in Salt Water and Pass Unscathed Through the Rough-and-Tumble of Battle. To Meet This Need the Industry Pooled its Knowledge and Trade Secrets. The New Weather-Proof Packaging Will Have Many Uses After the War

THERE IS a revolution coming in the packaging and shipping methods of thousands of products which travel via railroads, steamships, trucks, and airplanes. The change will come because fiber-board containers—both solid and corrugated types—do not have to be kept perfectly dry any more. The V-Board weather-proof fiber-board container has solved the dampness problem, and in a great big way.

Right now, nobody knows more than a tiny fraction of what the possibilities of this container are. It was developed for the emergencies of tossing cartons of war goods into the surf while landing operations were going on under fire, and for stacking goods out in the open on tropical islands for weeks and weeks where the rainfall is more than ten feet a year. And the armed forces are taking as much of this packaging material as can be made.

But shippers and container makers, looking ahead, see the reduction or elimination of troubles which have be-deviled them for years. To understand what they see, it is necessary to look back at the brief history of the V-Board.

The layman sees fiber-board containers in every grocery store, and they all look alike to him. There is, however, many a secret kink and quirk to the making of them, many a formula which is kept locked away in a good strong safe. And these secrets are not the simple bits of lore with which a watchmaker might manipulate tiny metal parts; they are the kinds which apply to huge and slow moving machines, vast tonnages of raw materials, enormous investments of working capital.

For 30 years every large maker of containers tried to solve the weather resistance problem. Naturally, each applied all his secret methods and every bit of knowledge he could gain from the outside. The stakes were huge. Getting the right answer would have given leadership of the industry to any company. But no one hit the jack pot.

POOLING KNOWLEDGE—When war needs demanded a weather-proof container, these manufacturers got together to exchange information. They were willing to lay all their facts on a common table and to pool their patents. And the facts proved to be enough. A fiber container could be made which would not be destroyed by 24 hours of immersion.

First came the solid fiber box. Here the hard problem was to seal the edges of the board. Plastics licked that one.

The corrugated box was harder. At every area where the corrugated inner sheet touches the outer or inner wall, glue must be applied. The manufacturers had to find a glue which would continue to hold although the spaces between the corrugations were filled with water and kept that way for 24 hours. By co-operative action they found one.

Production got under way, and everything looked good. But there was trouble to be expected. It would come from those secret methods. The kinks and quirks in use in one plant were bound to turn out more successful weather-proof containers than those in another, and nobody could guess which plant would be the winner.

The industry decided to head th one off. Each plant listed the types equipment it intended to use, the siz operating speeds, inspection method everything that would let one pla know what was going on in anoth All this was gathered into a book a given to the production executiv Now any plant which was havi trouble could look up and see wh its competitors were doing.

The product of the whole indus had to come up to the standard set the military men. There was only sensible procedure to take. An indu try-wide inspecting system was set Under this, each manufacturer s three sample boxes from each or filled—and if the order was larger th one carload, then three from each c load—to a single testing laborat which served the entire industry.

ABILITY WAS SHARED—The laborato in turn, made a monthly tabulated port to the entire industry. Each fact making shipments during that mo was identified by a number—a la



Official U. S. Navy Photograph

In war, the ten-thousand-and-one items needed by our armed forces must be packaged to stand rough handling and outdoor storage, as this picture makes clea

company like Robert Gair might have several plants represented and each of these would have a different number, these being scattered through the list and not grouped.

Here the presence of those secret processes began making itself apparent. Some plants were making very good records, in that nearly all their samples were well above standard, while others were not doing so well.

Meetings to discuss these reports were turned into open forums in which the manufacturers who had the worst records discussed their troubles. Very quickly it became clear that many of these problems could not be solved by talk and by reports alone. The personal touch would be needed.

Right here the industry took the step which promises most for the future of the weather-proof container. It made arrangements for men from the successful plants to visit the unsuccessful ones and give personal explanations of how to make those small changes in methods which can make such big differences in results. Secret kinks and quirks, in short, were being taken from plant to plant, and by the very men who knew best how to use them. The industry at last was making an all-out, all-coördinated attack on this decades-old problem. And so successful was this method that failures have been reduced almost to the vanishing point.

Development did not stop there, since many high-powered outfits were interested in the weather-proof container. Big companies like American Cyanamid and Du Pont and National Adhesives were making chemicals for it, and wanted this business to grow.

And there were further possibilities. Full water-resistant protection of the contents of the containers was one of them. The container, as originally developed, is weather-proof only in that it will not disintegrate like an old-fashioned fiber-board container when wet. Water can leak in and get at the contents unless these in turn are protected by being wrapped in heat-sealed bags or by other means.

THE MARINES TAKE OVER—The United States Marine Corps were doing some testing on their own. They developed a plastics-backed adhesive tape. Sealed with this, the weather-proof containers were put on warehouse roofs in Philadelphia and left there through eight months of snow, rain, freezing cold, and broiling sun. The contents remained perfectly dry.

Wanting to give them a real workout, the Marines then soaked these tape-sealed containers in hot salt water at 125 degrees, Fahrenheit. And still the contents remained dry.

Then the leathernecks got rough. They filled 12 of the containers, tied them together with a steel cable, and towed them ten miles down Delaware Bay behind a speed-boat. The contents stayed dry and undamaged, and the Marines decided that they had a container.

The Army used a slower method. Experts were sent all over the world, everywhere that war goods were being delivered. They took colored motion pictures of containers in action. Significant bits of these were shown to the container makers. They showed containers being lowered in slings during rain storms, coming ashore on landing craft, being dredged up several days after having been tossed into the surf, riding over jungle trails after having stood for weeks in tropic rain and sun.

Never in the history of the container business has such a flood of information poured in from so many sources. From inside the industry, from suppliers of chemicals and materials, and from experience records all over the world, the container makers are learning what they can do and what they must do. The experience of decades is being crowded into weeks. And it is being shared by the whole industry. The battle for future business is wide open and every container maker has an equal chance.

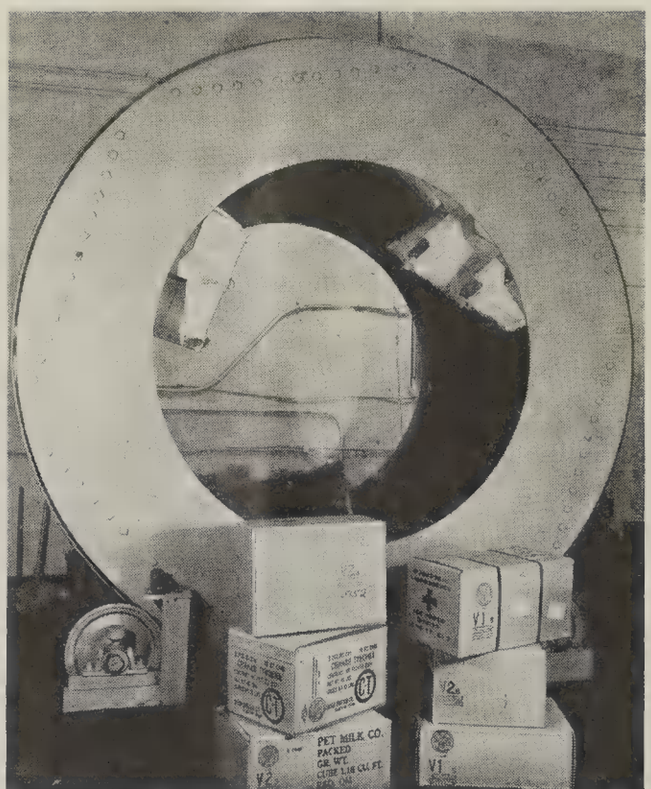
WEATHER-PROOFING COSTS MORE—Not everything in prospect for the weather-proof container is bright. The cost may be a stumbling block. In ordinary times an average sized container uses 10 square feet of fiber-board. If the average cost is taken at a nominal $7 a thousand square feet, that means seven cents for the container. The best grade weather-proof container may easily cost five times that, or 35 cents. Used in carload lots, with 7000 to 8000 filled containers in a carload, this would make a big difference to the shipper.

Against this there are mitigations. One of these is superior strength in the same weight. The weather-proof container is more than twice as strong as the ordinary one of the same grade. In many cases the shipper could cut 1½ pounds from the weight of each average sized container. That would mean 12,0000 pounds eliminated from many a carload. Important as this is to rail shippers, it will mean a lot more to trucks, most of all to airplanes. Incidentally, cutting the weight of the container in half will halve the cost disadvantage against it.

Packaging structures will be helped. Many a package is a study in civil engineering, with the contents themselves bracing the box and all sorts of members added to distribute the stresses. Put twice the strength in the outer shell and many a bothersome bit can come out of the inside. This will reduce the overall costs and sometimes may make the weather-proof package the cheaper one.

Stiffness is important. At all ordinary relative humidities, the weather-proof container is a good 4 percent stiffer than the ordinary one, and this means superior ability of filled containers to stand up under handling by lift trucks or when piled in high tiers. But there is more to it than that.

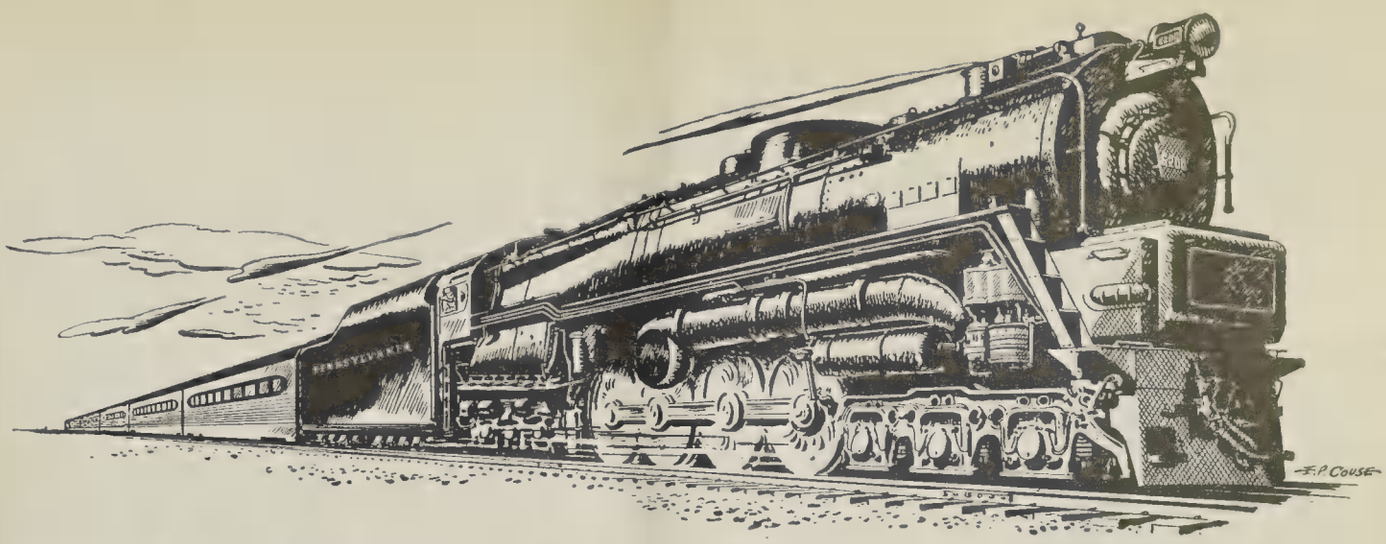
Ordinary containers lose stiffness quite rapidly as the relative humidities of the atmosphere about them increase. It is not wise to store them in such damp places as ordinary refrigerators. But the weather-proof container loses stiffness only slightly and very slowly under damp conditions. Filled or unfilled, it can be stored in refrigerators and in buildings which are much too high in relative humidity for the ordinary ones.



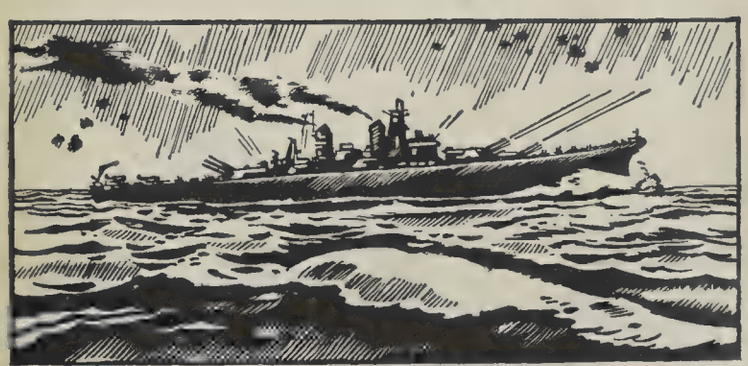
In order to subject V-boxes to the rough treatment and strain they would receive in actual use, this massive tumbling drum was designed and built. In it, loaded cartons receive more strenuous handling than they would in use on the world's war-fronts

Courtesy Container Testing Laboratory

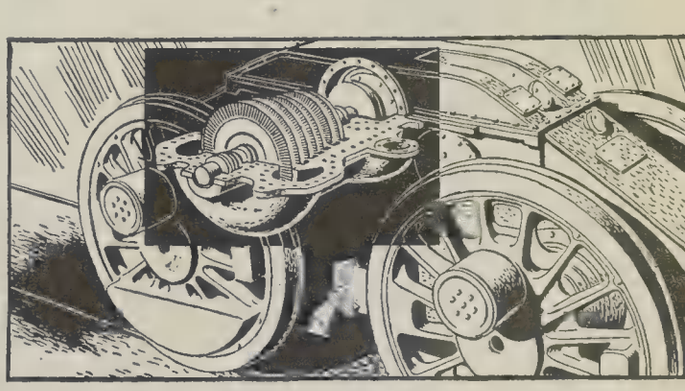
EXPANDING DEMAND EXPECTED—In fact, this retention of strength and stiffness when they are damp is opening to the weather-proof container fields previously closed to the fiber-board container industry. Packaging of fresh meats and of fresh fruits and vegetables are examples. Right now, live lobsters are being shipped from the seacoast to interior points in weather-proof containers carried by airplanes. Farmers can take the weather-proof containers right out into the open fields, pack and seal them full of damp produce, and have that produce reach the market before the dew upon it dries. This opportunity alone can cause the weather-proof container to double the



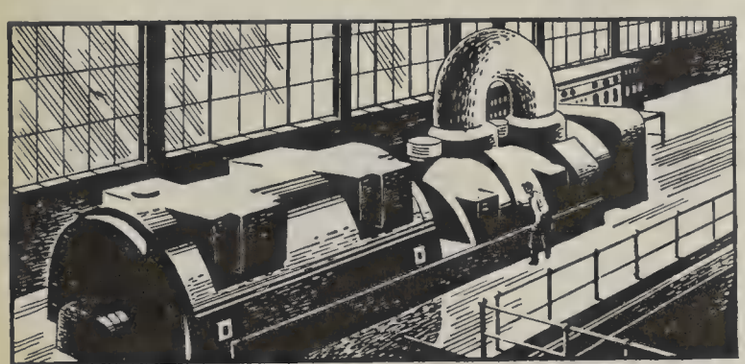
This Newest Locomotive
is Powered Like a Battleship



LONG AGO successfully developed by Westinghouse for ocean vessels, the *steam turbine* has now been harnessed as a brand new type of smooth, efficient motive power for modern railroad locomotives.



THE WESTINGHOUSE steam turbine in the Pennsylv Railroad's new direct-drive locomotive is *no bigger* t a household electric refrigerator—yet it will haul passenger trains with ease.



THE POWER-PACKED locomotive turbine is a descendant of giant Westinghouse turbines which generate much of the electricity used today. The great expansion of electric power began with these turbines.



THE VELVETY FLOW of power from this 6,900 horsepo *steam turbine* locomotive will make trains run with smoothness and is a major contribution to finer tr portation for the future.

THE RAILROADS are developing a dazzling new kind of transportation for the future. The latest and most dramatic improvement is *steam turbine* power, which gives the Iron Horse "new lungs."

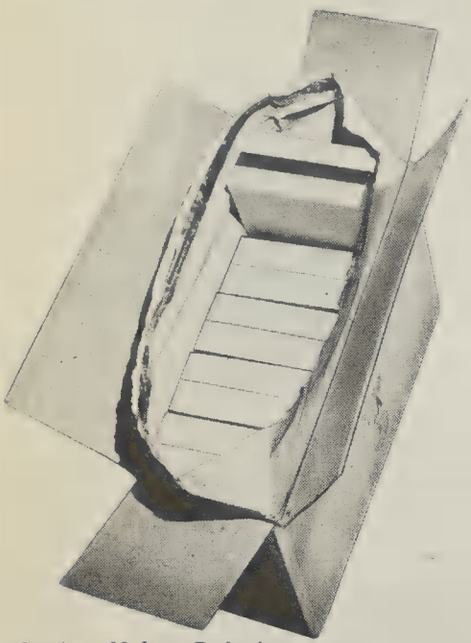
To help produce this new locomotive, the Pennsylvania Railroad, a long-time pioneer in transportation improvements, turned to Westinghouse and the Baldwin Locomotive Works. Working as a team, these companies have produced this latest in a great line of steam locomotives—descended from "Old Ironsides," built by Matthias Baldwin in 1832. *Westinghouse Electr & Manufacturing Company, Pittsburgh 30, Pennsylvania.*

Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Westinghouse presents: **JOHN CHARLES THOMAS—*Sunday 2:30 pm, EWT, NBC***

pre-war sales of the industry and open wide new fields of demand.

Fire damage can be reduced. Anybody who has seen a stack of ordinary cartons turned to a pile of mush by water, with cans or other contents scattered all through it, knows why hose and sprinkler damage is so often



Courtesy Modern Packaging

Vital medical supplies for our armed forces are packaged in V-Board boxes

a separate item on fire insurance policies and the biggest single factor in fire damage. The weather-proof cartons will burn in the flame but they will not dissolve in the water.

Use by exporters will be heavy. Our armed forces are making the weather-proof container known all over the world. Protection of the contents will be important enough in this field, but doubled strength (or the same strength with less weight) will have high value, too. Many an exported box has to be carried inland over the roughest of truck trails, or by airplane to jungle landing fields, or even on the heads of native carriers.

Ability to re-use the container after it is emptied is a major factor in exporting. The extreme strength and durability of the weather-proof container will be a foreign sales asset to any goods packed in it. Right now our soldiers are using these containers as roofs over their fox holes and for many another weather-resisting job. But in peace-time those who get these containers abroad may use them to package other goods, perhaps for shipment back to us.

The whole story is not known yet. Container makers keep on finding out how to reduce production costs, add new qualities, figure out new grades with varying degrees of weather resistance. Not all peace-time packages will need to withstand 24 hours immersion in sea water; there is room for varying degrees of weather proofness at varying prices.

But two things are sure. A problem which has been studied for 30 years has been solved by co-operation of a depth and intensity seldom found in any industry. The resulting weather-proof container is going to solve many a tough problem for post-war shippers.

MAGNESIUM FIRES

Can be Controlled By Sprinkler Systems

FIRES in plants where magnesium is machined are dangerous because molten magnesium has the ability to take oxygen from water and thus perpetuate its own combustion.

This hazard has caused many factories to avoid all use of magnesium, while others, as we have noted before, went so far as to specify the kinds of underwear girl operatives might wear, lest a frictional spark from silk panties should reach the machinery and cause the magnesium to ignite.

Recently concluded tests, made jointly by the National Board of Fire Underwriters and the Factory Insurance Association, have shown that magnesium fires can be controlled by sprinklers.

The drops of water from the sprinklers, striking the fire, do cause small explosions during which bits of molten magnesium fly through the air. But these bits are so small and they cool so rapidly that they will not ignite other piles of magnesium chips which are only a few feet distant from the fire. And when enough drops of water have struck the fire it is cooled to the point where it ceases to burn.

Molten magnesium flowing into, or being struck by, solid bodies of water, such as might come from hose streams or be lying on the floor as a result of hose streams, is quite another matter. In this case the magnesium fire will give off enough hot gases and steam to damage or destroy any ordinary building.

Control by sprinklers, then, must bring the sprinklers into action at the earliest practicable minute and must not provide solid bodies of water into which the molten magnesium will flow. But, with careful lay-out and safeguards, the sprinkler system will reduce the magnesium fire hazard to the toleration point for far more machine shops than was believed practicable a year ago.

SET AND SHRINK

Plastics Parts Used In Assemblies

RIVETS, grommets, dowels, and pins made of thermosetting plastics are coming into ever widening use as parts assemblers gain greater experience with them.

The basic technique of applying these parts usually includes the application of heat to fit them into the spaces they are to occupy, then permitting them to cool. Under heat, assisted by pressure, the plastics parts flow until they are upset, enlarged, split, bent, or otherwise formed to hold the pieces they are to join. Then, when the heat is removed, the plastics parts not only set themselves permanently to the shapes into which they have been formed, but also shrink and thus tighten the joints.

Enough heat for the flowing and setting often may be had from the friction of spinning rivet heads, spinning grommet ends, or expanding sleeves by the use of friction tools. Other parts are expanded by compressed air and, instead of cooling the air in an after-cooler or inter-cooler attached to the compressor, the air is allowed to retain its heat of compression, this being sufficient to set the plastic.

Applying heat in the process of squeezing rivets is, of course, a common operation which presents no problems.

Not the least of the advantages of these fasteners is that their shrinking action tends to increase the strength of the thin materials which they join by pre-stressing those materials.

SHEAVES

Have Plastics Faces To Reduce Wear

WIRE rope men long have known that the damage done to the rope at the sheave may be the greatest source of rope failure.

In large airplanes the cables are run over sheaves which have contact faces made of Formica. This resilient plastic offers a gentle, cushioning surface to the rope, which tends to reduce inner friction between the wire strands and to prevent wear. Furthermore, the resilient surface has no filing or abrasive action upon the strands of the rope.

Every sheave is mounted on anti-friction bearings which have the lubricant



Resilient plastic facing on sheaves saves wire rope in many industries

so retained that they will withstand years of service without additional lubrication. This minimizes the running friction of the sheave and therefore the frictional resistance to the movements of the rope.

Sheaves of this type will find many post-war applications, especially where small-diameter wire ropes are used as linkage for remote controls.

Plastics Days Ahead

Railroad Modernization Will Offer Many Diverse Applications of Plastic Some of Which Have Already been Proved in Practice. Lighting Fixture Upholstery and Drapery Fabrics, Structural Parts, and Electrical Insulation are a Few of the Possible Uses of these Versatile Materials

MODERNIZATION . . . renovation . . . rebuilding—words to bring tears to the eyes of hard-pressed railroad men. In this war of "movement," domestic rail transportation systems have had to bear a huge burden of bringing raw materials to production plants, moving finished and semi-finished products to points of trans-shipment, transporting troops, moving war workers to and from their jobs and, at one and the same time, keeping civilian economy and morale at a high level.

With production at an all-time high, facilities that would normally be called upon to relieve the railroads have been drastically curtailed or entirely suspended for the duration. Thus there is today no commercial transportation by water between our two coasts. Shortages of tires, gasoline, and new automobiles—with the 35 mile an hour speed limit thrown in to slow things down still further—have combined to reduce the amount of freight and the number of passengers that can be moved by truck and private car.

Swamped with business as a result of these losses in total transportation capacity, railroads felt the pinch from yet another side. The demands of war left little material and even fewer facilities that could be devoted to the construction of new transportation equipment. Thus railroad officials have been forced to put back into service freight and passenger cars they had long marked off as useless, leaving dreams and plans for modernization, renovation, and rebuilding for the days after peace returns.

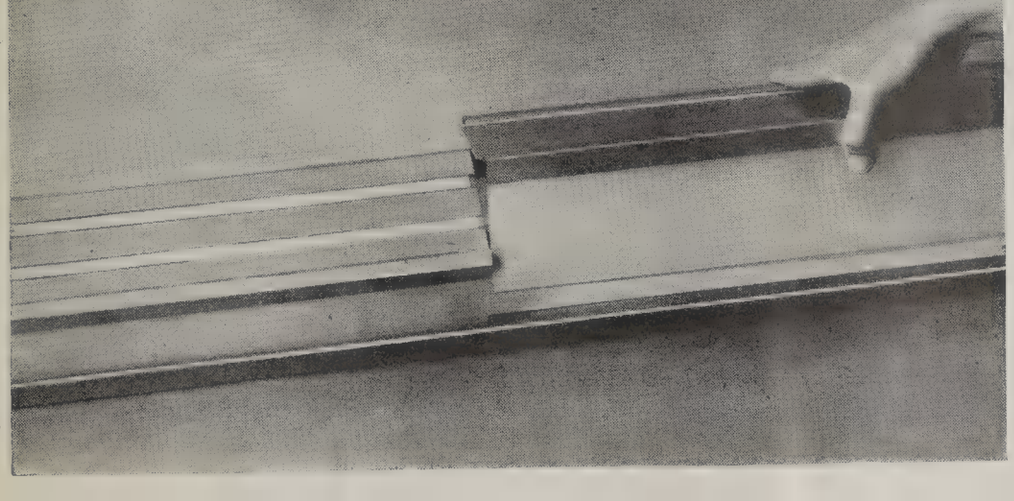
But it is with these dreams and plans of railroad men that plastics is most concerned. For a few years before the war, travelers were given a brief but intriguing glimpse of a new trend in railroad car design based on the premise that rail travel can be made a comfortable and pleasant experience. It is to be expected that these improvements—many of which depend for their success upon the use of various plastics materials—will be further refined when the country returns to peacetime economy and will find acceptance in a large proportion of our future rail cars.

BETTER CAR LIGHTING—An important factor contributing to the luxurious atmosphere in the last passenger cars to be put into pre-war service was proper lighting. Lighting fixtures were designed to provide adequate illumination for comfortable eye-saving reading and to fit into the interior decorations. However, in addition to the usual problems of the lighting engineer—candlepower, shadows, glare—railroad lighting installations must meet certain special requirements.

Below: acrylic resin with appliqued strips of sheet metal is used in this lighting fixture for passenger cars. The resilience of the plastics holds the fixture snugly in place

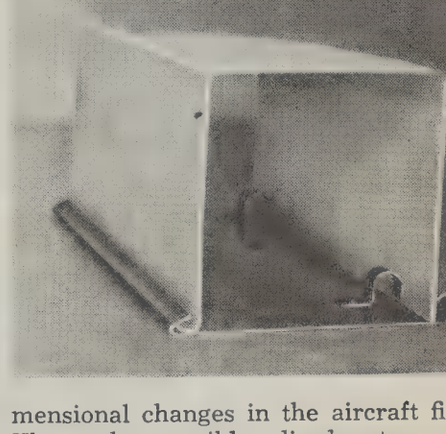
Right: In this picture, metal applique has been removed to show how the acrylic sheet has been turned along the edge so as to snap into grooves

Courtesy Safety Car Heating & Lighting Co.



They must, above all, be rugged a dependable so that valuable rolli stock will not be tied up for repeat repairs, and must have a life as lo as that expected of the car itself. addition, the fixtures must be simp and accessible—permitting quick a easy cleaning and maintenance—as w as economical and efficient. Final railroad lighting must meet such oth requirements as lightness, ease of i stallation, safety, and freedom fr rattling and other annoying noises

Faced with these requirements, Safety Car Heating and Lighting Co pany started working with plast shades, finally adopting white tra lucent Plexiglas for their railro lighting fixtures. The company fou this material to be tough and capa of withstanding hard blows and flexing caused by the weaving mot of the car. It was light in weight, sh ter-proof and rattle-proof, and it h proved the permanence of its opti properties and its freedom from



mensional changes in the aircraft fi The only possible disadvantage— fact that it might soften and deform the temperature of the fixture ceeded 160 degrees, Fahrenheit— circumvented by the use of fluores lamps.

An ingeniously simple method mounting, developed by this compa depends for its success on the flexib of the acrylic resin. The shades formed to the desired shape, wit slight outward flange along the ed The piece can be flexed so that shade may be snapped into two par

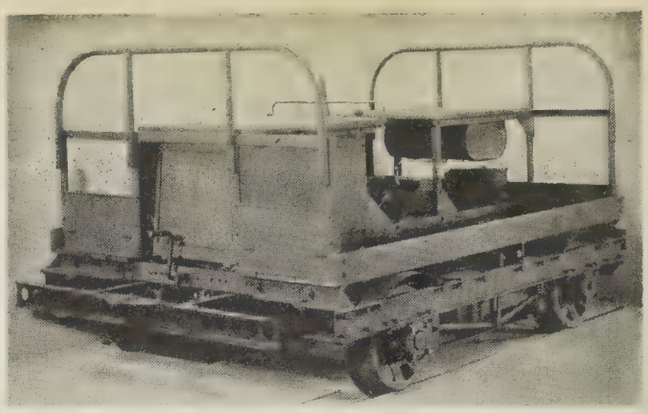
channels. This installation, which permits quick and easy removal of the shields, has proved extremely versatile.

For long troughs running the length of the car, 24- to 48-inch lengths of shade have been used, separated by rigid reinforcing spacers molded from white translucent acrylic resin. Modifications include troughs which zig-zag back and forth across the ceiling of the car and those which run intermittently along the car ceiling, valence, or side wall.

Developments in home lighting during the past year may well have an influence on railroad light fixtures in the post-war period. Finding that a considerable portion of the public look upon fluorescent fixtures as cold and unsympathetic, Morris Sanders, an industrial designer, has developed several lighting fixtures composed of tough extruded Lumarith strips interlaced, crimped, and pleated to form an infinite variety of interesting and distinctive designs. For example, one fixture uses extruded plastics strips in the form of louvers, held in place by metal rods which are covered with plastic tubing to render them almost invisible. In another design, a corrugated sheet of cellulose acetate, 3/32-inch or less in thickness, rests on glass rods slipped through molded acetate rings.

UPHOLSTERY FABRICS—During the past few months, subway riders and commuters to and from some of our larger cities have been playing guinea pig in tests to determine the wearing qualities of various synthetic and coated fabrics. These riders plucked and pushed at the brightly colored seat covers, anxious to learn for themselves just how these synthetic textiles feel and wear.

Designs for the interiors of tavern lounge cars, parlor cars, observation lounge cars, and dining cars, as developed by Edward G. Budd Manufacturing Company, indicate that synthetic textiles will have wide application on our nation's railroads when new and redesigned cars can be produced once more. Interiors thus far worked out by this company suggest the use of these materials as window drapes as well as for coverings on dining chairs, divans, and club chairs.



Fitted between the wheels and axles of this handcar, sleeves molded of phenolic prevent it from activating the electric signal system

Courtesy Monsanto Chemical Company

STRUCTURAL PLASTICS—During the past year or so, the use of plastics as structural materials has aroused intense interest and active speculation among engineers and builders as well as among the members of the plastics industry itself. In England this development is being given its first railroading tests by the Southern Railway Company. This railroad has put into service the first of 10 luggage vans—the baggage cars of the United States—whose sides, ends, and roof are built of reinforced laminated plastics panels.

The panels of these railroad vans are given increased strength by the use of steel wires and cotton, interwoven on a power loom. This construction, in which, for example, 24 high-tensile steel wires and cotton threads to the inch are woven in both the warp and the weft, has made it possible for Reinforced Plastics Inc. to overcome one of the principal drawbacks to most laminates—their brittleness. The material—woven so as to be interlocking—can be varied to meet requirements by the selection and arrangement of the steel wires.

Although this steel-cotton material is very strong, it lacks the stiffness needed for rolling stock work when used alone. Consequently, after being taken from the loom, the fabric is passed through an impregnating machine where it absorbs sufficient phenolic resin to achieve the necessary rigidity. From the bath the material is removed to the drying oven, then to the cutter where it is divided into sheets of the desired size. At this stage in the process the reinforced material is placed in a press between sheets of ordinary impregnated material and subjected for about 75 minutes to a pressure of approximately one ton to the square inch.

Tests carried out on this material show it to have an ultimate tensile strength, both longitudinally and transversely, of over 24,000 pounds per square inch, and a bolt hole tensile of 21,900 pounds per square inch. The comparatively light weight of the fabric is evidenced by a specific gravity for one-ply steel wire-cotton embedded in laminated paper or fabric of 1.65 as against 7.83 for steel. Another advantage of this laminate is a high impact strength.

In the case of the first experimental luggage van, these characteristics of the reinforced material have meant a lighter car with greater cubic capacity. Compared with a steel panelled luggage van, the test car using the new laminate for its sides, ends, and roof affords a net reduction in tare weight of 5600 pounds. But at the same time this new van has a capacity of 1848 cubic feet as compared with 1808 cubic feet for the standard model.

With the adoption of this reinforced plastics laminate in the panelling of the luggage van went a thorough redesign of the entire car. It was thought advisable, in view of the characteristics of the material, to rebuild the carriage of the van completely in a way that would protect the body from shock. The most convenient method of accomplishing this was to separate the body from the main frame of the van and introduce a spring cushioning device which would allow the body to move longitudinally a few inches and then return to its normal position. With the body thus cushioned and protected from buffing or draw stresses, it could be considerably lightened without danger to baggage.

FREIGHT CARS—In the United States, the Great Northern Railway Company is in the process of constructing, of plywood and light-weight metals, 1000



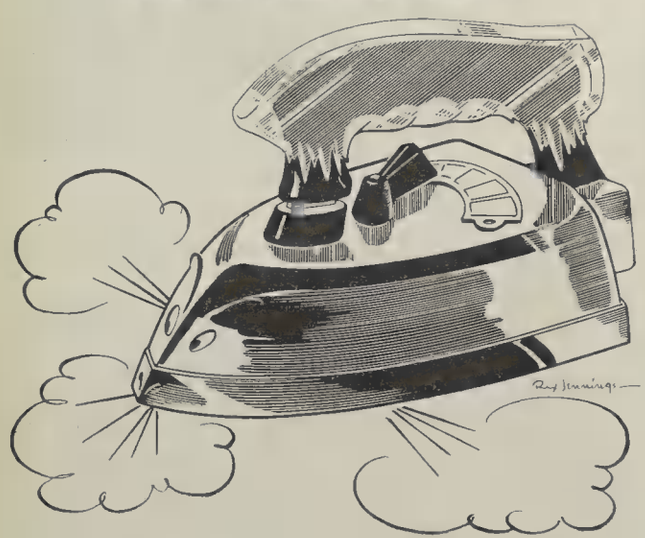
Plexiglas shades used on zigzag ceiling lights in a lounge car

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

MOLDING COMPOUNDS



HOW TO GET A COOL GRIP ON A HOT ITEM

Perhaps the handle on your family iron is molded of a Durez phenolic plastic. If so, there'll be no burned fingers from this handle because the heat resistant Durez phenolic does not conduct the heat of the iron. Also notice the smooth glossy finish. Feel the pleasing touch. These, too, are permanent features. Heat resistance is one of many outstanding properties of Durez phenolic molding compounds. Others are dielectric strength, diversity of finishes, excellent moldability, and resistance to moisture, temperature extremes, acids and alkalies. There are more than 300 Durez compounds contributing towards the furtherance of the war effort on a scope that is practically all-embracing. The unusual versatility which Durez phenolics are demonstrating today, reflects the wide usage of these compounds in manufacturing the many new items for post-victory markets.

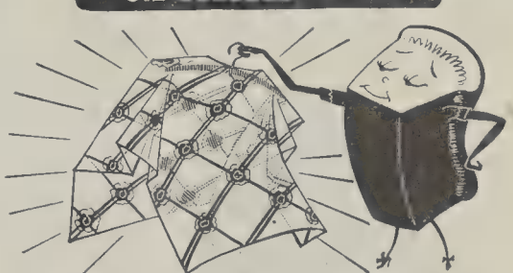
INDUSTRIAL RESINS



"ROPING" NEW MARKETS

Co-Ro-Lite — a combination of rope fibre and Durez phenolic resin — is an ingenious development of the Columbian Rope Company. This remarkable material offers two important advantages to the manufacturer. First is the high impact strength gained from the interlaced network of wiry rope fibres impregnated with tough Durez phenolic resin. Second is the speed and ease with which Co-Ro-Lite can be molded into compound curves. Wartime proven, Co-Ro-Lite promises to be the selection of many postwar manufacturers.

OIL SOLUBLE RESINS



PARTY DRESS FOR DAILY WEAR

Durez 220, a new type phenolic resin, is now being used with amazing success in bread wrapper and similar type printing. This remarkable resin, added to ink, brings about the most instantaneous set under heat. One of the several outstanding Durez phenolic resins, 220 is another example of the continuing progress of Durez technicians in developing resins that are leaders in their respective fields.

In developing their imaginative ideas, scientists the country over have come to rely on the versatility of phenolic plastics. For these most-versatile-of-all plastics offer a wide selection of properties from which to select a plastic that precisely fits the job. During the past quarter century, Durez has been specializing in the production of phenolic plastics from molding compounds through industrial resins to the oil soluble resins. Through active participation in successful product development on a scope that includes practically all fields of industry, Durez technicians have acquired a rich background and a wealth of data. The complete operation of the Durez organizat is assured to those who are interes in developing practical industrial pr ucts. Durez Plastics & Chemicals, I 523 Walck Road, N. Tonawanda, N

PLASTICS THAT FIT THE JOB

standard freight cars, 40 feet in length, and weighing approximately 50 tons. While the cost of producing these cars is almost the same as for conventional box cars, a saving in weight of two tons is effected. The phenolic resin adhesives used in the manufacture of the exterior-type plywood is set under pressures of from 175 to 200 pounds per square inch, at temperatures that range from 260 and 285 degrees, Fahrenheit. In the case of most standard panels, the press time is 5½ to 8½ minutes.

Used for both the inside and outside of these box cars, the panels are riveted at horizontal points to lumber stiffeners. The thin metal strips that cover the vertical joints between the outside panels are bolted through to the lumber studding. On the interior walls the panels are installed horizontally, with thinner panels employed for the ceiling.

Even further down the scale in railroading, plastics find their uses. In many railway motor cars produced by Fairmont Railway Motors, Inc., molded Resinox parts serve as a medium of electrical insulation between wheels and axles. On most railroads, signal systems are tripped when an electrical contact is made between the two rails of a track. Maintenance cars, however, are intended to be manhandled off the track when a train approaches and should at no time activate the signal system. They must, therefore, be insulated to prevent contact between the rails; and the best place to provide such insulation is between the wheel mounting and the axle.

Since wheels on lighter hand-cars are pressed on the axle and held there by a threaded nut, the desired insulation is provided by a phenolic sleeve, molded by Northwest Plastics Inc., which fits between the wheel hub and the axle. In heavier cars, however, the wheels are each bolted by eight bolts to a flange on the bearing. To provide insulation in this instance, a matching flange of high-impact cord-filled phenolic, molded by the same company, is inserted between the wheel hub and the mounting plate to prevent metal-to-metal contact. Each bolt is fitted with a vulcanized fiber bushing.

These applications of plastics to railroading give but a hint of the many and diverse applications that will be found for these materials when present plans move from the drawing board to the road.

PLASTICS PUMPS

Aid War-Time Safety, Pave Way for Peace-Time Uses

THE HAND-OPERATED pumps which are standard equipment on Army and Navy life rafts for use in case of failure or loss of the cylinder of CO_2 gas normally used to inflate these rubber boats, should have many peace-time functions.



Emergency hand pumps for inflating life rafts make good use of plastics

Pre-war pumps of this type had metal cylinders which tended to corrode to such an extent that the plungers stuck in the barrel or were extremely difficult to operate. Also, the sheet metal tubing dented easily and, once dented, was of no further use. These disadvantages have been ended by using plastics for the barrel, end caps, and inner support of the flexible tubing in the Peters and Russell pumps.

The phenolic resin impregnated paper barrel, instead of denting under a blow will, at most, crack. In such contingency, a hand clamped over the crack is sufficient to maintain pressure within the tube. Regardless of the extremes of weather in which the pumps are used, neither the phenolic end caps, the laminated plastic barrel, nor the Tenite II (cellulose acetate butyrate) flexible coil inside the tubing will corrode when subject to salt water and bad weather.

PLASTICS HANGARS

Provide Protection for Aircraft Mechanics

TO INSURE that necessary maintenance work on our Navy airplanes goes on despite vagaries of weather, the United States Navy supplies portable vinyl-chloride acetate impregnated canvas-covered hangars to its many outposts. Whether the field is in the Far North or close to the Equator, the canvas covering offers full protection. The material is not only processed against the ravages of fire, mildew, and rotting but given treatment which keeps it flexible at 40 degrees below zero. Furthermore, when work is finished at one field, the canvas can be easily rolled up and moved forward to the next advanced base.

Although the original hangars were constructed for servicing only one plane at a time, the units now in use are large enough for a two-motored plane to be serviced at one end while a four-motored plane is being repaired at the other. The design is such that planes are placed half in and half out of the hangar, with special canvas socks slipped over the motors and fuselages



Vinylite-impregnated canvas over a steel frame makes a portable hangar

and laced to the canvas end pieces to seal the openings.

Each hangar consists of a steel arch covered with Vinylite-impregnated canvas. The Textileather Corporation calenders a 0.004-inch film on single-texture duck and then laminates two sheets together with a wet solution. The laminating is not done when the canvas is calendered because inequalities in the cloth might cause a leak, whereas the laminating solution seals in the material to give high hydrostatic resistance when it is added in a second operation. In the next step the two sheets, which are now laminated together, are impregnated with a solution containing a vinyl-resin base which is resistant to fire, water, and mildew. After this processing the completed fabric is dipped in a bath.

Drying time is about two minutes in an oven that is maintained at a temperature of 275 degrees, Fahrenheit. From start to finish the entire treatment of a given batch of canvas requires little more than 8 hours—a speed that makes it possible for the company to turn out 12,500 yards of 36-inch material in one day.

Since speed in erection is of great importance, the canvas is divided into easily handled sections by Newcastle Products Company and its subcontractors—the fabricators of the hangars. Thus, a total of 21 panels are employed to cover the front, back, and roof of the hangar. A variety of light-weight canvas socks are necessary to provide a tight seal around the openings in the canvas end curtain where a plane's motor and fuselage project into the hangar. These socks are square, slit at the bottom, and equipped with draw strings for tightening the canvas around the nacelle. The sides of the sock lace to the grommet strip on the inside of the curtain. The steel frame is built by International Derrick and Equipment Division, International-Stacey Corporation, and Milwaukee Iron Works.

Planes and Trains

In Designing the Modern Streamlined, Lightweight Train, the Railroads Sought Assistance from Aeronautical Engineers, and this Successful Example of Working Together by the Two Industries Points the Way to A Future Integration of their Services for the Good of the Public

THERE are two contrasting aspects in the relationship between aviation and the railroads. One, technological and non-controversial, covers the many advances in railroad equipment which owe their origin to aeronautical science. The other, economic, political, and bitterly controversial, is concerned with the participation of the railroads, direct or indirect, in air transportation.

In this article the technological advances can be discussed unhesitatingly with pleasure and pride. In considering the possible role of the railroads in air transportation, however, it is wiser to do nothing more than state possibilities and set forth the arguments of both sides. The right decisions must come from public opinion and Congress, and will be years in the making.

In discussing what the railroads have drawn from aeronautics there are two main lines of advance to consider: The first is the reduction of air resistance of the train; the second the reduction of its weight.

STREAMLINING SAVES POWER—Only 20 years ago, air resistance was considered by railroad mechanical engineers to be a minor matter. So great was the misunderstanding of air resistance that at one time it was lumped with ground friction resistance. Hence, the forms of locomotives as well as passenger and freight cars remained almost ideally suited for creating air disturbances. This was no handicap in suburban traffic where passenger trains operate at low speeds. But at speeds of 60 to 70 miles an hour, the power expended in overcoming air resistance accounts for at least one half the power exercised by the locomotive.

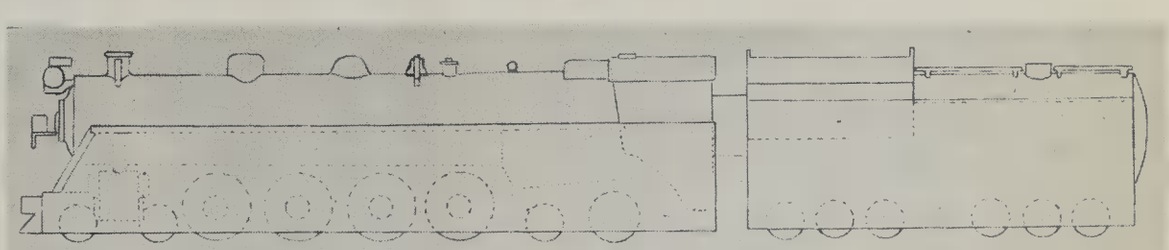
Skilled design can cut this resistance to approximately one half the amount encountered by the un-streamlined locomotive and train. We stress the word "approximately" because so much depends upon the design, condition, and length of the train, as well as additional factors. Hence no generalized statement can be made in spite of innumerable tests and voluminous writings on the subject. Whether the power saving be one half or less than one half, streamlining is evidently fully worthwhile. Not only do our streamlined trains have an enormous advertising value, since they spell to the public a great advance in railroad equipment, but they actually do provide savings in power and, hence, in fuel.

Aeronautical science's second contribution to the railroads has been in aiding better structural design of rolling stock so as to reduce weight. When an aircraft engineer of our acquaintance was first requisitioned by a railroad equipment company to assist in the design of a streamlined train, he asked for examples of stress analyses and load factors, and was greatly surprised to learn that they were not available. Locomotives and trains had become structurally strong through tradition, experience, and the brutal addition of weight.

No attempt had ever been made to utilize light alloys or high-strength steel alloys. Because the engineers who pioneered in the design of streamlined railroad equipment were, on the whole, familiar or made themselves familiar with aircraft practice, they departed from the traditional path and did several things. They made bold use of the light aluminum alloys without which modern aviation would hardly have been possible. Or, alternatively, they made use of the stainless steels of very high tensile strength, and reinforced them skilfully against local buckling by appropriate corrugation.

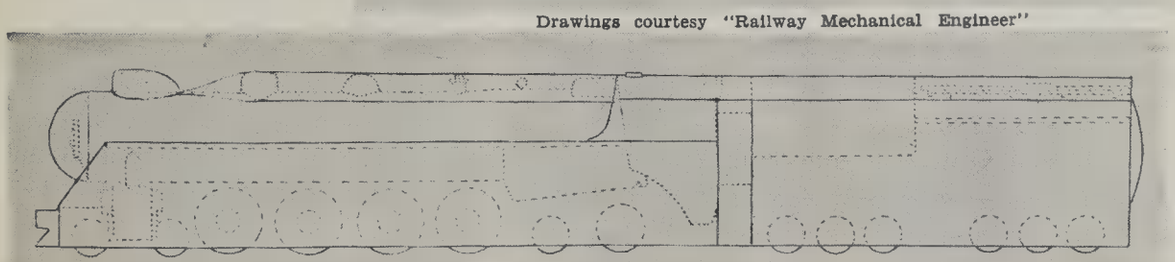
Then, when it came to the actual task of design, they worked out a theory of shock loads. In addition, they investigated the conditions under which a railroad train would encounter the most severe loads. They discovered the points of application of such loads and their directions, and designed extremely refined structures accordingly.

By following aircraft practice, the weight of car equipment has been reduced by nearly 50 percent. One authority states that the 750 tons represented by the heavy conventional cars in an eight-car train can be reduced to 400 tons, approximately. Such a saving would reflect itself in the cost of motive power with consequent effect on fixed charges, fuel costs, and the like. While the railroads so far have not been able to take full advantage of these weight-reducing elements except in their most expensive trains, there is little doubt that in post-war



The first step in streamlining locomotives was to shield the lower part with sheet metal. The dots show the parts that were masked to cut down air resistance

Drawings courtesy "Railway Mechanical Engineer"



This drawing indicates how streamlining was carried to further lengths by shielding the front end and the upper part of the boiler so as to provide unimpeded airflow

trains the process of weight reduction will be accelerated and become more general.

REDUCING VIBRATION—Another important way in which aeronautics has influenced the railroads is in the study of vibration. In aircraft work from the earliest days, it became apparent that the isolation of engine vibration from the rest of the airframe was a vital matter. Rubber engine mountings were found indispensable. The study of flutter of aircraft wings was seen to be an absolute preliminary to safety. Moreover, it was discovered that the reduction of vibration was a



subtle business and not merely a matter of adding weight. There have been cases of locomotives experiencing failures because of vibration, and weight, added as a remedy, caused the vibration troubles to increase enormously.

Aviation taught American engineers that vibration was a subject to be treated with all the resources of applied mathematics and applied mechanics. Our modern streamlined trains with their remarkable smooth-running qualities are evidence of the fact that in vibration, also, railroad equipment designers owe much to their aviation confréres.

SHALL RAILROADS FLY?—In the early days of flight, neither railroads nor steamship operators, with few exceptions, showed much interest in aviation. Today, many surface carriers are keenly interested. Steamship companies, railroads, bus lines, and truck operators have filed applications with the Civil Aeronautics Board for certificates of public convenience and necessity authorizing air operations. But existing airlines are, in general, hostile. The Department of Justice has expressed its interest through formal intervention, and the issue has recently been discussed in Congressional Committees and on the floor of Congress.

What is the nature of this conflict? The Civil Aeronautics Act, passed in 1938, has been regarded by Congress as well as the Civil Aeronautics Board and the aeronautical industries as having been planned to prevent control of air carriers by surface carriers such as railroads and steamship lines. Perhaps the best way to define such views is to quote from testimony before the House Interstate and Foreign Committee by L. Welch Pogue, chairman of the C. A. B.: "The Act (now law) of 1938 provides that consolidations, mergers, and acquisitions of control involving air carriers are unlawful unless it is found that they will not be inconsistent with the public interest . . . it was the intention of Congress to carefully restrict the participation of surface carriers in the air transport field. The requirement was construed to mean that aircraft must be used in a manner which would be auxiliary supplemental (subordinate) to the surface transportation of the acquiring company." Here is something as clear and definite as the testimony of a public official before a Congressional Committee can be. The question today is whether this view shall continue or legislation should be enacted to give railroads and steamships a freer, stronger hand in air-transport operation.

THE CASE FOR THE RAILROADS—There are many persuasive arguments in favor of such participation. The first is the avoidance of duplication in personnel and other facilities. There are many ways in which surface carrier facilities, intangible assets, and personnel can contribute to air-transportation service without a proportionate increase in investment and expense. It is argued also that if a single company were permitted to operate both rail and air, the most economical and sound division of traffic would become possible. Again, it is said that air cargo could be carried much more cheaply if all the facilities of surface transportation were coördinated with air equipment, and that similarly, economy could be gained in the carrying of passengers. Certainly, in war-time, air-surface coördination works splendidly and there are many arguments in favor of the idea that coördination in peace-time would be equally efficient.



Three examples of differently powered streamlined engines. Upper left: An Illinois Central Diesel-electric locomotive. Above: A streamlined steam locomotive on the New York Central. Right: A steam-electric engine of the Union Pacific line

THE CASE AGAINST—Airlines' spokesmen who oppose the entry of the railroads into the field of aviation say that the projected "integrated transportation companies" would be huge transportation monopolies. The railroads, they argue, had every opportunity to develop air transportation for nearly 15 years and they failed to grasp the opportunity. They point out that the development of air transport was left to independently-owned and financed airlines who went forward despite obstacles and in the face of great financial loss.

"Now, however, the surface interests have moved in," says one of these spokesmen, Captain Eddie Rickenbacker, president of Eastern Air Lines. "They want to reap the harvest and dole out its fruits to the American public in the manner which will best protect their vested interests in their ground facilities. . . For air transportation to come under the control of the powerfully financed surface carriers with their interlocking relationships and their vested loyalties in their railroads and steamships would doom free enterprise in air transportation."

It is possible that Rickenbacker may state his case too strongly. It is perfectly true, however, that heavy pressure is being exercised by railroad, steamship, truck, and bus interests to break down the legislative barriers guarding the airways against invasion.

COMPETITION NEEDED—There is also one argument which Rickenbacker did not use, which nevertheless deserves to go down in the record. There are benefits to be derived from the very existence of different and competing types of transportation. Such rivalry, of course, if pushed to extremes, with passenger fares and cargo tariffs completely unregulated, would make competition ruinous to both airlines and railroads. But the C.A.B. and the Interstate Commerce Commission have a great deal to say regarding rates and know fully what evils unrestricted competition may bring.



On the other hand, it can be said that it is precisely the competition of the airlines which has stimulated progress on the railroads. It is the one and a half hour schedule by air between New York and Washington which has indirectly led to the four-hour Congressional Limited of the Pennsylvania Railroad. It is the tremendous speed of the transport plane which is fostering the growth of the streamlined train. It is the enterprise and friendly attitude of the airlines towards the travelling public that is fostering a similar outlook by the railroads.

Another argument against railroad operation of the airlines belongs in the field of psychology. The railroads could, to a large extent, supplant lack of experience in air operation by hiring the best talent available, and by drawing on the personnel of the airlines or the Air Transport Command. But the railroad man quite rightly loves his industry. He loves the locomotive and the whole world of railroad operation which is so fascinating and varied.

A decade or more would perhaps be necessary before railroad men had the same loving understanding of aviation work. It would be misinterpreting human nature to think that railroad men at the top could operate airlines with the same flexibility and enthusiasm which young aviation executives like Juan Trippe, C. R. Smith, and many others have shown for their own chosen form of transportation.

AIR-RAIL CO-OPERATION NEEDED—Whatever the outcome of the argument before public opinion and Congress may be, there is one thing which must not be forgotten. The two great methods of transport can co-operate in many ways, whatever the status of legislation may be now or may become in the future.

The desirability of such co-operation was recognized very early in France, Great Britain, Germany, and, to some extent, in the United States. Thus, Major Martin Wronsky, Director of the German Lufthansa, revealed that in 1928 an agreement was signed between the Deutsche Lufthansa and the German railroads whereby offices for the receipt of air cargo were established in every railroad station, and the railroads become responsible for delivery of cargo to the nearest airport.

In 1928, or soon thereafter, Lufthansa and the railroads also had arrangements (similar to our own) whereby railroads took care of air passengers stranded by bad weather.

Major Wronsky further advocated in 1935 the coördination of railroad timetables and airline schedules. In some cases fast ground expresses were eliminated in Germany because the air gave a completely satisfactory alternative service. Combination rail and air tickets were issued, with as much justification as combination tickets are issued for all American railroads.

Similar views were expressed by Raoul Doutry, Director General of the French Chemins de Fer de l'Etat.

Methods of American coördination between railroads and airlines will suggest themselves to almost anyone who travels or ships goods. Travelers should be able to buy at one place tickets for all airlines as well as all railroads and bus lines. Likewise, business should be able to ship by air to points from which railroad or other surface transportation will carry on. Common sense will dictate other co-operational possibilities.

Whatever may be the contents of new legislation, it is clear that the airlines are too strongly established to be dominated by the railroads. On the other hand, it can be expected that the railroads will ultimately seek the maximum coördination with the air lines, whether this is encouraged by legislation or not.

A solution to the problem will be achieved. It is one of the great blessings of American life that no one-sided, authoritarian power is allowed to dominate a situation. Hence the public can anticipate, sooner or later, a reasonable adjustment and friendly relationship between the two great industries.

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PRODUCE BY AIR

Fruits and Vegetables Are Potential Air Cargo

THE WAR has given birth to a new concept of cargo-carrying capacity of the airplane, and there is no doubt that in the post-war period the airplane will be responsible for a great deal of traffic. The problem is to determine in what directions air cargo should be sought, what equipment will be needed to carry air cargo most efficiently, and to what level costs per ton mile must be reduced so that the airplane can, in addition to having much higher speed, compete with other forms of transportation on more favorable terms as regards cost.

Colonel Edward S. Evans of Detroit has generously made possible a study of "Air-Cargo Potential in Fresh Fruits and Vegetables," conducted by Professor A. Larsen at Wayne University and presented in a scholarly and well documented pamphlet. Professor Larsen has made it the purpose of his monograph to secure basic information from numerous sources such as the Department of Agriculture, Department of Commerce, railroads, trucking companies, terminal produce handlers, and so on. At 15 cents a ton-mile, he concludes, the fruits and vegetables carried by air would be insignificant in volume. At three cents a ton-mile fully 25 percent of the gross traffic in fresh produce, or upwards of 4 billion ton-miles per year, would be carried by air. Of course, three cents a ton-mile is a very optimistic figure, and ten cents a ton-mile would be much more likely. But even at ten cents a ton-mile, there is evidently a great potential market. The more fragile and expensive fruits would come first—strawberries and peaches for example. Then would come cantaloupes, cherries, plums, and so on. At very low rates even the lowly lettuce and tomato might become air travelers.

Non-perishable farm products are not likely to be airborne for many years to come. From air traffic there will come many benefits, such as fresher fruits, with less chance of damage, savings in stock carried, in rentals, in interest, and the like.

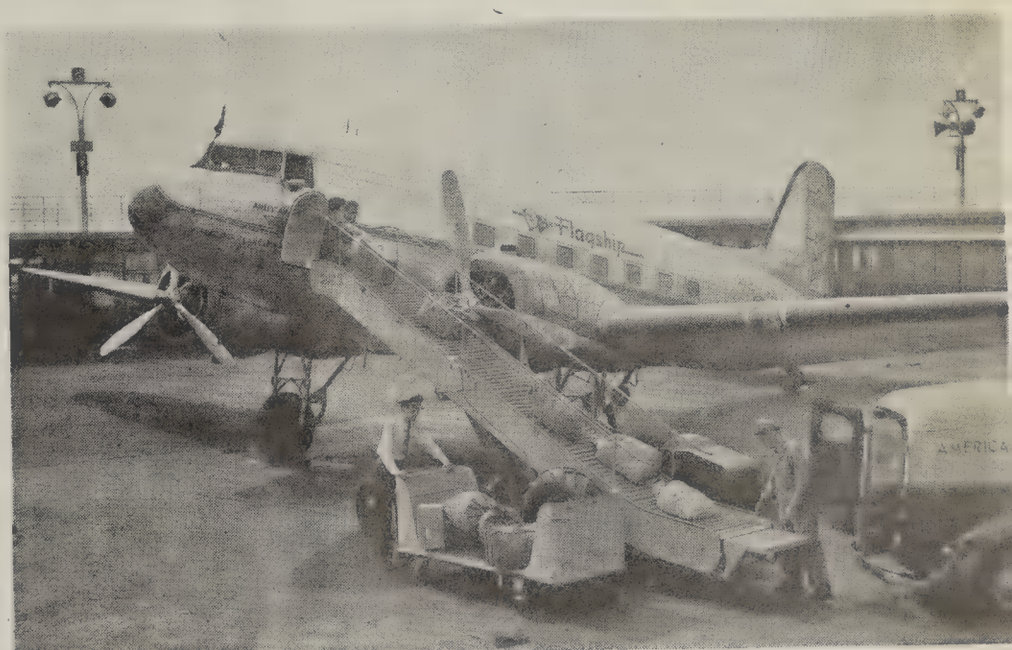
AIRPLANE LOADER

Has Self-Contained Power Plant

A COMPLETELY portable and mechanized unit for loading and unloading air cargo has been put into use by American Airlines. A conveyor belt is mounted on a gasoline-powered tractor which keeps a continuous stream of baggage, express, and mail moving from truck to plane as fast as cargo handlers inside the plane can stow it away. The conveyor can be adjusted to the height of the forward cabin of the Douglas DC-3 or the post-war DC-4.

Both the operating and the elevating mechanisms are hydraulically operated. At the lower end of the conveyor belt is a platform to receive cargo coming down the conveyor, from which it may be placed on the low-level panel trucks on which passengers' baggage is carried, or on the regular mail and express delivery trucks.

When the much larger transports such as the DC-4's or DC-6's come into service, the conveyor will put the passengers themselves on board, and even now they are used as escalators for the captain and crew of the DC-3. The credit for the actual construction of this equipment is due to the Lyon-Raymond Corporation.



Adjustable for height, the conveyor belt is powered by a tractor engine

Electronics In Railroading

Increased Safety is the Goal of Many Uses, Direct and Indirect, of Electronics by the Railways. Flaw Detection in Rails, Materials Testing, Signal Systems, and Communications All Involve the Busy Electron

By JOHN MARKUS
Associate Editor, *Electronics*

DESPITE the pressure of war-time operations the American railroads have been continuing their constant search for new devices to improve operation. Faced with post-war competition from motor trucks, airlines, pipelines, and passenger cars, the railroads are taking a keen interest in electronic equipment, not only for signaling and communication, but also for testing materials used in the manufacture of rolling stock and equipment.

One of the lesser known electronic instruments used by the railroads is the Sperry rail flaw detector. This instrument, developed by Dr. Elmer Sperry in 1927, has found wide application since that time. During 1943, 17 fissure detector cars were operated by Sperry Rail Service and traveled from coast to coast and as far north as Hudson Bay. Besides the rail-testing electronic equipment, each car contains a cook's galley, shower bath, and sleeping quarters for the crew of five.

The cars are self-propelled by gas-electric drive and move over the tracks at a speed of from six to nine miles an hour, stopping each time a defect is found. Usually working from dawn to dusk, they cover about 30 miles in a 12-hour day.

As the car moves, an operator keeps a constant check on the condition of the rails by watching a recording tape. Defective portions of a rail show up as irregularities on this tape when the search unit attached to the car passes over them. The electronic equipment actuates the recorder to cause a distorted line to appear on the tape. Defective sections are sprayed with white paint for identification and are then further examined by hand-testing as a follow-up operation.

Investigation of 142,000 miles of rail with the electronic equipment during 1942 resulted in removal of nearly 100,000 defective rails. About 160,000 miles of rail were tested during 1943.

MATERIALS TESTING — Widespread use of electronic testing and examination of ferrous and nonferrous raw materials in the metallurgical industries means further application of electronic instruments to promote the safety of railroad travel. Already the cyclograph, the electron microscope, the spectrophotometer, and the mass spectrometer have been rather widely applied to the raw materials that go into the making of railroad engines and cars. Although ear-marked now for war products, such electronic devices will be increasingly used in the post-war period.

A boon to heavily laden passengers is seen in the recently demonstrated electronic door opener for sleeping cars. In a car now riding the rails of the Canadian Pacific, doors open automatically when the handle is touched, not turned. The mere contact sets electronic circuits in operation, actuating the door-opening mechanism for entry or exit.



Radio enables the engineer of this Baltimore and Ohio switching engine to receive his orders. The antenna of the receiver-transmitter is seen on the cab roof over the headlight

SIGNALS SYSTEMS — One of the most pressing problems confronting railroads for many years has been that of block protection. By means of an electric signal system, each rail route is divided into blocks or sections of track which no two passenger trains may occupy at the same time. Thus no train may enter a block already occupied and collision is prevented. The signals on this system are manually operated and are susceptible to human error. To remedy this, an automatic block system was developed about 70 years ago. Today, of a total of 160,000 miles of track for passenger trains in this country, about 140,000 miles have automatic or non-automatic block signals while 8000 miles are equipped with automatic train-stop or train-control devices.

In 1922, the application of radio communication to railroad service received careful study by a committee of the Association of American Railroads while at the same time a number of individual railroads conducted research to study operation under varying conditions of service. Even than it was anticipated that short-range sets would meet the emergency requirements caused by floods, storms, and so on, for marooned trains and for use by train crews and construction crews. Automatic train control and signaling were also predicted.

RADIO SYSTEMS—About a dozen different types of electronic devices have been tried by the railroads. These fall into three general classifications; carrier telephone systems using the rails as conductors; induction radio systems using side-of-track wires; and radio systems through the ether. By 1928 each of these methods had been tried by at least one railroad with considerable success.

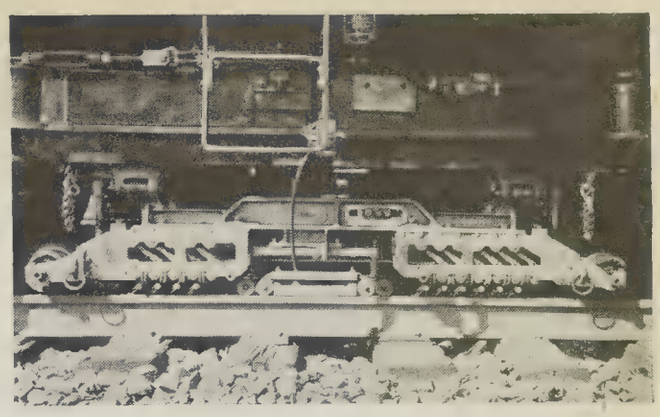
In that year, a report on radio equipment used on a freight train of the Chesapeake & Ohio stated that a saving of two or three tons of coal per trip was noticed for a particular engine because of shortened trips. Considerable saving of time also resulted when trouble developed en route, since the crew could be directed to the fault and have it repaired before a man could walk the full length of the train. By notifying the engine crew when flagmen had been called in, speedup of operation resulted, as well as elimination of the chance that the flagman might be left behind, a not infrequent occurrence. Handling of trains in dense fogs and snowstorms that prevented the use of hand signals was expedited as well.

When radio was first applied to rail-



Left: Sperry car used to detect rail flaws by electronics

Right: The detector unit or sled is made up of coils which ride the rails on small wheels



roads, frequencies around 2500 kilocycles were used and radio equipment designed to operate at this frequency used rather high power. For example, the transmitter on the Virginian Railway in 1925 had three 50-watt transmitting tubes, larger and more costly than was desirable.

At that time, the growing aviation industry was clamoring at Washington for operating frequencies in this same mobile band, and the Federal Radio Commission decided that the railroads had failed to show either public need or real desire for the radio frequencies already allotted to them. Until such time as the railroads could show need based on reasons of public interest, or until they could find a band of frequencies not urgently required for other services, the Commission was reluctant to allocate frequencies. This retarded railroad radio development. No further work was done until recently when the technique of utilizing ultra-high frequencies for this purpose was perfected.

ULTRA-HIGH FREQUENCY—Above 30,000 kilocycles, radio waves travel very much in the manner of light and do not follow the curvature of the earth or spread around intervening objects as do the longer waves used for broadcasting. Thus, their range is limited. With elevated antennas, considerable range can be obtained, but with lower antennas only a short range is possible. Intervening objects are not necessarily complete shields, and even with low antennas there is no great difficulty in covering a limited number of miles with these ultra-high frequencies.

This makes these high frequencies entirely suitable for local service, as between the two ends of a freight train. It has the added advantage that the same frequency can be used simultaneously in many different places without likelihood of interference unless the stations are near each other.

Recently, a frequency above 150 megacycles was used by the Baltimore & Ohio to demonstrate how radio can expedite the handling of freight trains in terminals. This installation for yard and train operations provided means for the chief dispatcher in the Baltimore area to contact and issue orders to moving trains, and permitted train crews to talk by radio telephone between the engine and caboose, as well as with the train dispatcher.

During the trial run, the conductor used a two-way radio in the caboose. He directed the switching out of a group of cars along the tracks, on orders from the dispatcher, and at the same time maintained radio contact with the dispatcher for other matters. Communication with the engineer of the train was provided by a second two-way unit mounted in the engine. This served as a flexible communication system for modifying orders without delaying the movements of the train.



Above: Using a hand unit to recheck findings registered by the flaw detector

Right: These cross-sections of defective rail were cut to verify the accuracy of the electronic instruments



In the office of the chief dispatcher was a telephone handset which was connected to a transmitter on top of the Baltimore & Ohio office building. Amplitude-modulated signals were transmitted at a power of 50 watts.

The units mounted in the engine and caboose had a power of only 5 watts. One unit was installed in the engine cab, with a telephone handset located beside the engineer's seat. In the caboose, the unit was mounted on a table. Power was supplied by storage batteries. Antennas were installed on the roof of the engine cab and caboose.

To overcome the high noise level in both engine and caboose, loudspeakers were employed for calling purposes. After contact is made, conversations are conducted with telephone handsets.

Maintenance cost of the units for locomotives is slightly higher than that of a radio in an automobile, such as a police or Army scout car, due to the greater vibration of the train, but this added maintenance cost is far outweighed by the savings in time, manpower, and cost of fuel in the operation of the locomotive.

TALKING THROUGH RAILS—Second in popularity for moving trains is the carrier current system. In this method, electronic equipment is connected to the rails of the roadbed and to wires paralleling the track. Since the telephone conversations are not broadcast into the ether, there is no need for a definite frequency assignment by the Federal Communications Commission. Secrecy of communication is also insured for the same reason, and there is no possibility of interference with other broadcast services.

For some time, the various stations on the Milwaukee divisions of the Chicago, Milwaukee & St. Paul have been communicating with one another by use of the carrier current system. Last summer experiments were begun to determine the feasibility of installing equipment on trains passing over that division.

At the FCC hearing, the Louisville & Nashville and Kansas City-Southern Lines testified that they obtained good results in tests with the carrier system but also recommended radio for end-to-end communications. Testimony from the Chicago, Burlington & Quincy Railroad, the New York, New Haven & Hartford, the Seaboard Airline, the New York Central, and the Chicago, Rock Island & Pacific highlighted the use of radio rather than the carrier system.

In the West, where terrain is mountainous, and there are long hauls

through open country with no wire-lines alongside trackage, heavy storms and snow frequently paralyze wire communications. Carrier current systems which depend on wayside wires for transmission of the signal, are therefore not suitable. Operating under these conditions, the Santa Fe, the Chicago, Burlington & Quincy, and the Denver, Rio Grande & Western favor use of radio over their lines rather than carrier systems.

Some advantages set forth for the carrier system were: (1) no necessity to use valuable radio channels or licensed operators; (2) signals carry from 10 to 20 miles between moving trains and from 50 to 100 between a moving train and a wayside station; (3) signals are restricted to this range, and do not diffuse or interfere with other wire communications on railroad properties.

The advantages of space radio put forward were: (1) no wire lines parallel to tracks; (2) while no interference has yet occurred between the carrier systems tested on railroads and wire lines of Western Union and the the telephone company, such interference may occur; (3) carrier current is not suitable in congested areas where many railroads enter the same terminal; (4) use of the ultra-high radio frequencies with either AM or FM does away with most noise interference associated with early tests with space radio at lower frequencies; (5) space radio would work in cases where it was not practicable to use the carrier method and was needed to supplement the carrier system.

FOR GREATER SAFETY—Use of radio on trains, not only for accident prevention but also to bring help more quickly to the scene of wrecks, was urged at the hearings. Both head and rear ends of trains are seldom damaged at the same time in wrecks. A radio signal from a wrecked train would be picked up over a 50-mile area by radio-equipped police cars or other emergency radio units. After the big Atlantic Coastline wreck in December, 1943, men had to go three miles to a telephone to call for help. Radio equipment on all common carriers would result in savings of lives and property by bringing rescue squads quickly.

The possible use of facsimile reproducing equipment for railroad use was described by John Hogan, president of Facsimile, Inc. He told of successful tests using facsimile between a wayside station and a Rock Island moving train over a 12-mile distance. Other future developments described were Western Union's interest in frequencies for railroads as a means of giving telegraph service to passengers on moving trains, and the Bell System's interest in supplying train passengers with public telephone service. Both companies testified that they are ready to co-operate with the railroads.

In spite of visual warning signals, signs, and gates, many accidents still occur at grade crossings. A step in the alleviation of this problem is indicated by the recent application to the Federal Communications Commission by the radio division of Bendix Aviation Corporation for a license to broadcast railroad crossing warnings to automobiles on frequencies from 60 to 75 megacycles. An arrangement similar to this was used for some time on the George Washington Bridge across the Hudson River to give instructions to motorists.

One objection to electronic equipment that has impeded its adoption by railroads is the seeming fragility of its vacuum tubes. But this objection is yielding ground in the face of the widespread knowledge that such equipment is used in tanks, aircraft, ships, and other vehicles by the armed forces, where impact due to shock is usually far greater than in peace-time machinery. The performance records made by electronics under the trying conditions of this war cannot go unheeded.

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FURNACE CONTROL

Actuated by Electronic Means

WHEN the flame fails in furnaces fired by pulverized coal, oil, or gas, electronic flame-failure safeguards can prevent the development of explosion hazards. The equipment shuts off the fuel supply and attracts the operator's attention by a signal. Such systems may be modified by the addition of various interlocks, furnace purges, automatic ignition, relights, timers, alarms, and other devices.

Operation of the equipment depends upon detecting a flame's existence by a phototube or an electrode, or both. Furnaces burning pulverized coal or oil, in which flame luminosity is light yellow or brighter, generally use the phototube detector. Ordinarily a blue flame, such as gas burners make, requires an electrode-type detector which responds to the presence or absence of a flame having an electrical resistance of from 1 to 100 megohms.

When flame failure occurs, the resulting change in the current through the phototube or electrode exposed to the flame is amplified by electronic tubes to the value needed by a relay to shut off the fuel valves.

MICA TESTING

Permits Use of Otherwise Discarded Material

TWO NEW electronic test sets detect conducting regions in raw sheet mica and measure the dielectric loss of the raw mica in "block" form.

One test set determines loss by measuring the power factor of the current flowing through the mica when high-frequency voltage is applied across it. Since ordinary methods of measuring power factor are too slow for a commercial test of this type, an electronic circuit was designed that gave a suitable measure of loss as a single reading of a volt-meter.

To discover conducting regions in stained mica prior to the power-factor test, a battery-operated spark coil was used. A sheet of mica is placed on the test plate and the test point is moved over its surface. Any defective regions are indicated by sparking at or in the vicinity of the point. Only a few seconds are required for each test.

By the use of these two test sets, a large quantity of block muscovite mica, considered unusable for capacitors by the previous methods, was selected and used in about 40,000 capacitors by several manufacturers.

INSULATING GLASS

Qualities Demonstrated With Sensitive Electronic Tester

AN ELECTRONIC potentiometer is being used to demonstrate dramatically the insulating qualities of a newly developed Libby-Owens-Ford built-in transparent window insulation called Thermopane. A Brown Instrument Company electronic potentiometer is used in comparing the difference in insulating quality between the new product and a single pane of glass in test cabinet windows.

In the demonstration, thermocouples were attached to inside and outside surfaces of both windows in the cabinet and with an inside temperature of approximately zero, the electronic potentiometer instantly picked up and recorded a difference of 20 degrees between the exterior surfaces of ordinary glass and Thermopane.

WIRE TESTER

Reveals Breaks in Covering Insulation

FIELD telephone wire at a United States Army invasion base in southern England is tested for breaks by passing the wire through a metal pipe while it is being wound onto spools. The pipe and wire are connected in an electronic circuit. When a break in the insulation is encountered, a spark jumps between the pipe and the wire and causes a bell to ring.

INFRA-RED BAKING

Offers Advantages to Bread Industry

BETTER loaves in less time is the claim advanced for a novel bread-baking machine that uses infra-red rays instead of oven heat.

Individual pans containing the dough are slowly carried on an endless chain past batteries of adjustable reflector-equipped infra-red lamps of the type already in common use in paint-drying and enamel-baking machines. Since infra-red rays are more penetrating than ordinary heat, baking begins in the heart of the load practically as quickly as it does on the surface, and the process proceeds more evenly throughout. Smoother crust is another advantageous feature.

Chemistry Serves The Railroads

Important Contributions Have Been Made to the Great Forward Strides in Speed and Comfort by the Railroads in the Last Ten Years. Chemistry Has Helped in the Achievement of Lighter Rolling Stock, Lessening of Boiler Scale, More Efficient Lubrication, Better Fuels, and Air Conditioning

CHEMISTRY is inescapable. Even in the conservative atmosphere of America's great railroad systems, products of chemical research and of chemical industry are constantly utilized. In fact, an important part in the continuing railroad revolution can be traced to applications of chemistry to the problem of faster, cheaper rail transportation.

That these chemical aspects are not obtrusive comes from the innate conservatism of railroading and from the consequent gradual adoption and adaptation of the many improvements which differentiate today's trains from those of a decade and more ago.

Changes cannot happen quickly on the railroads, since the processes of evolution operate slowly through the immense size and intricate ramifications of the systems. During the early years of the present century, necessity made safety the guiding thought, slogan, and credo of American railroads. Everything any railroad man does must first be considered in its effect on safety before action is taken.

This reaction has been so carefully cultivated over such a long period that the entire railroad world is built up around the thought of safety. Thus any change must be carefully studied and analyzed in order to make completely sure that it produces no reduction in the factor of safety.

Also contributing to railroad conservatism is the necessity that all rolling stock on all railroads be completely interchangeable between one and the others. Freight once loaded into a car must reach its destination even on a different road without needing to be reloaded into another car because of some difference of habit between the carriers involved. In the same way the design and construction of roads and rights of way must conform even down to minor details to rigid standards established to insure safe interchangeability of equipment.

Thus it is that newer modes of transportation, by highway and by air, have advanced swiftly, compared with the slow progress of the railroad revolution. But it is a revolution in spite of appearances. The changes basic to the revolution are increased speed of trains, increased power of locomotives needed to move heavier trains faster, and increased comfort of passengers.

It seems strange to discuss these points at a time when the railroads are staggering under the load of war-time traffic and when none of their services even approaches normal. However, the present situation, with its high rate of obsolescence and the difficulty of replacing old equipment, is laying a foundation for much more rapid improvement in the future.

The obvious railroad problem is to raise the overall efficiency of transportation, its only salable product. This means, first of all, faster trains. And greater speed can be attained in two ways: by increasing power of, or by lightening loads on, locomotives.

COAL AND STEAM STILL RULE—Railroad prime movers are now largely, and probably will continue to be, coal fired steam locomotives, in spite of their already very close approach to maximum economical size. The reasons for the railroads' preoccupation with steam locomotives are readily understood on the basis of their conservatism, and the fact that each of the important systems was planned to include access to a coal field of its own, with the additional fact of the cheapness of this form of power. Thus, in spite of the immense amount of attention lately given both Diesel and electric locomotives, these newer types supply what yet amounts to only a small fraction of the power consumed on our railroads.

Obviously, then, any increase in the efficiency and power of the railroads must be realized by improving the efficiency of steam locomotives. Yet this must be accomplished within the limitations of cross-section imposed by tunnels, bridges, and other structures on the rights of way; within the lengths permitted by the minimum radius of curvature of the track; and within the weight limits that can be safely carried by bridges and trestles.

When these limitations are considered, greatly increased power seems quite impossible to realize except by raising steam pressures; and that in turn meets structural limitations inherent in the peculiar form of the locomotive



Courtesy Permutit Corporation

By chemical means this Permutit Spaulding Precipitator treats water for the prevention of locomotive boiler scale. Its capacity is 400 gallons a minute

boiler and the necessity for so many strengthening staybolts as to decrease circulation. Actually, the power output of today's locomotives has been increased by more than 50 percent over those of World War I by the very important expedient of increasing their efficiency.

The steps by which this has been accomplished have involved mechanical changes in the structure and moving parts of the locomotive. These changes were made possible principally because alloy steels of high strength permitted lightening moving parts. Important among them were redesign of the running gear to increase its efficiency; lightening connecting rods by making them of alloy steels to reduce inertia loads; and improvements in wheel design to balance rotating loads more accurately at higher speeds. Basically these improvements have depended on the appropriate use of the increasingly valuable alloy steels and cast irons available through combined chemical and metallurgical development.

LOSING WEIGHT — The use of high-strength alloys, both those containing large percentages of alloying elements available before Pearl Harbor and the efficient low percentage emergency alloys of the war period, is giving railway mechanical engineers a new and important group of materials. The availability of these metals has led to an entire reconsideration of the design problems of cars as well.

The old conception of a car, whether for passengers or freight, was a simple platform with a superstructure to protect passengers or lading from the weather. The entire strength of the structure was embodied in a central beam of great strength but also of great weight.

The necessity for reducing weight of cars as part of the program for greater speed led to consideration of the entire frame of the car as the strength member rather than merely its underframe. Engineers redesigned cars as tubes housing the lading rather than as platforms upon which loads rested.

Further economies of weight were effected by the substitution of welding for the heavier method of riveting steel structures together. These and other less obvious changes, largely based upon the use of light, strong alloys instead of the older low carbon steels, have made substantial savings in car weights.

In freight box cars this saving has amounted to about five tons per car without sacrificing load capacity or safety. That means an increase of 10 to 20 percent in the capacity of a train for pay load, or a corresponding economy of cost. Clearly this has been an important factor in enabling the railroads to carry their staggering wartime loads today and will be vital in their future services.

These changes and improvements in locomotive and freight equipment are far less apparent, but far more revolutionary, than the introduction of streamlining, air conditioning, and what may be called good housekeeping, into passenger trains. Using light metals—aluminum and its alloys—as well as alloy steels, car builders have completely discarded old designs and have built new cars of wonderful lightness and comfort. Speed is attained without the sacrifice of safety. In fact, safety is increased by lowered centers of gravity. Furthermore, a distinct economy of operation is gained as compared with the heavy cars of old design.



Courtesy Metal and Thermit Corporation
Thermit welding of railroad tracks

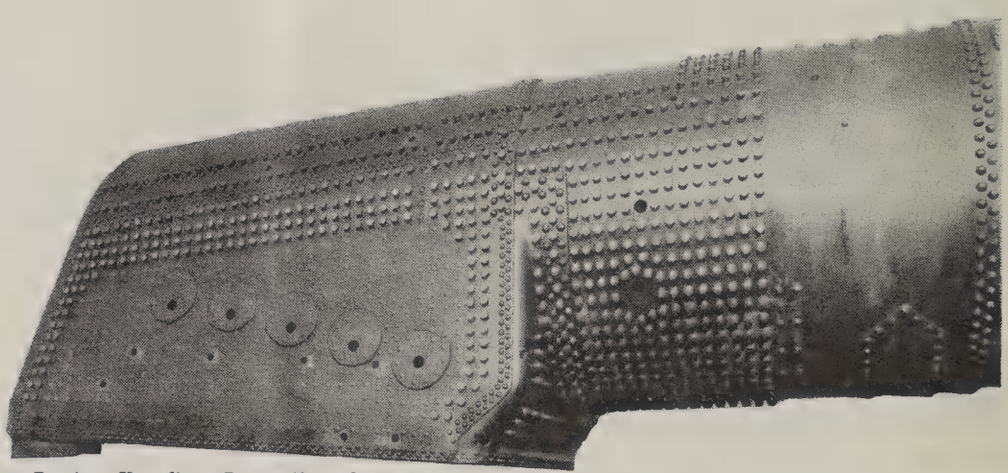
CHEMISTRY HELPED—These basic improvements rest upon vital chemical advances. The production of the elements (chromium, nickel, vanadium, molybdenum, and others essential in alloys) from their ores involves chemical processes of great nicety. The effective utilization of these metals in alloys employs the latest and best in metallurgical science. The light metals —aluminum, magnesium, and their alloys—are also products of chemical industry given special emphasis by war demands, and are already serving useful purposes on the railroads largely in sharp competition with alloy steels in reducing the weight of rolling stock. Their post-war roles in railroad transportation seem likely to be highly important in this country as they were in pre-war years abroad.

Few developments in recent years have been so useful in railroad work as that of welding techniques. Gas, electric, and thermit welding have each served valuable purposes in building and repair of railroad equipment. Welding has been particularly useful in reducing the weights of structures below those obtained with riveting, yet without sacrificing strength. Each of the standard methods of welding in their modern forms uses products of chemical industry essential in attaining superior results as compared with older techniques. In this, as in other fields, the great magnitude of railroad demand supplies a sharp goad to the development of methods and products needed.

SAVING THE SURFACE—Protection of the huge tonnages of steel and iron used in railroad equipment from the ravages of corrosion is a gigantic undertaking. Supplying of materials for this purpose alone supports an industry itself. Conditions for atmospheric corrosion encountered on railroads are particularly severe because of the presence of both cinders and sulfur dioxide in the smoke from locomotives burning soft coal.

Thus, both in magnitude and severity, this corrosion problem is exceptional and hence has stimulated the most important developments so far realized in this field. Furthermore, both architectural and engineering finishes are involved, so that the results of developments undertaken primarily by, and for the benefit of, the railroads actually serve everyone. Not only have chemists employed by the railroads engaged in this important endeavor, but those of coating manufacturers and of the chemical industry itself, supplier of the needed raw materials, have co-operated actively in the joint effort.

Similarly huge is the problem of supplying water to the boilers of thousands of steam locomotives traversing all parts of the country. The crux of the matter lies in wide variations in the character of water available even over relatively short distances. But that would be no problem, and was none of any magnitude, so long as boilers



Courtesy Vanadium Corporation of America
Manganese-vanadium firebox plates are used on this type of locomotive boiler

were operated well below their maximum capacities.

However, the whole completion of water supply changes, when, as now, the entire capacity of all motive power must be fully employed. This means that even slight variations in composition of water beyond recognized limits must be corrected to save steaming capacity that would be reduced by scale; to reduce corrosion and caustic embrittlement that constantly threaten boiler steel; and to minimize cleaning and blowdown needed to keep boilers free from sediment and objectionable concentrations of dissolved salts.

Water treatment is essentially a chemical process employing chemical products, and is necessarily carried out under chemical control to insure optimum results. While much of the technique of water treatment has been developed for other purposes, the variety of waters encountered on the railroads has stimulated a vast amount of research in this field, both by the carriers and by those who supply them.

OILING THE WHEELS—Railroad lubrication has assumed new aspects with the greatly increased speed of trains today. The adoption of improvements in all equipment—of more efficient bearings, of Diesel and electric power, and of higher temperatures and pressures employed in modern steam engines—has changed the lubrication problem significantly. New types of oils and greases must necessarily be employed following changes in the surfaces to be lubricated and their conditions of operation. Here, too, experience in other fields has had to be supplemented by developments carried through the final stages to fit lubricants precisely to their new roles in rail transportation. In this case, as in others, overall developments have greatly increased the loads on lubricants.

Air conditioning of passenger cars and refrigeration of freight cars owe much to chemical industry. These two closely related functions obviously will provide greater and greater service in the future. Clearly, the public wants both in very much their present forms, so far as results are concerned. However, the future seems sure to witness modifications of these two techniques to bring them closer together.

Air conditioning of freight space will serve the same purpose as refrigeration in the preservation of many perishable foodstuffs and will actually do it better. And few are able to differentiate between refrigeration and what passes for air conditioning of today's passenger cars. Chemical industry and chemical engineering research have already provided answers to these problems well in advance of present practice. They are now waiting for the railroads to put them to use.

CHEAPER FUELS—The problem of efficient use of fuel on the railroads is still a major one. Clearly, steam locomotives fired by coal will continue, probably for a minimum of many decades, to supply most railroad motive power for reasons already mentioned. Efforts to burn powdered coal



In its early research on the design of air conditioning systems for the railroads, the Carrier Corporation used an actual coach in which lights simulated the heat of the passengers

in locomotives have failed of full success, but have demonstrated that improved efficiencies are possible.

Oil firing has been accepted as approaching the ideal where oil is available on a reasonably competitive basis with coal. This points the way to a satisfactory solution: use of an oil-coal mixture of the type of the so-called "colloidal fuel," already successfully burned in marine boilers. Atomizing such a mixture of finely pulverized coal in oil gives a flame with the characteristics of oil flames yet actually burning principally cheaper coal.

Thus in the operation of American railroads at the increased efficiencies required to meet modern competition with other means of transport, one finds chemistry and chemical industry supplying vital materials and techniques. Some of these services were already serving other industries and were available for immediate adaptation to railroad needs. Others have been developed by the railroads themselves or at their instigation by others. Obviously, future progress in transportation by rail will more and more employ chemical developments.

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STARCH LACQUER

Has Resistance to Heat, Weather, and Solvents

ALLYL STARCH, a chemical derivative of starch made by its reaction with allyl chloride or bromide, has been shown to have valuable properties as a constituent of varnish and lacquer coatings. The freshly prepared compound is readily soluble in most paint and varnish solvents, but when the solution is applied to a surface and dried, the resulting coating cures to an insoluble state either by contact with the air or, better, by the application of heat.

The final coating is hard, transparent, and extremely resistant to weather and to solvents. It is also resistant to heat and will withstand 400 degrees, Fahrenheit. The development, now in the pilot-plant stage, is being conducted by the Department of Agriculture as an industrial outlet for farm products.

DICHLOROSTYRENE

Shows Promise in Synthetic Rubber

SYNTHETIC resins made by polymerization of dichlorostyrene instead of styrene possess both better electrical insulating properties and higher resistance to heat. The dichloro compound is also showing promise in synthetic rubber where it is polymerized with butadiene in a way similar to styrene. The new synthetic rubber is now undergoing exhaustive tests, particularly in heavy truck tires, where its heat resistance is important.

Dichlorostyrene itself is highly active and readily polymerizes to resins resembling the polystyrenes in most of their properties, particularly chemical resistance, solubility, and appearance. The point of heat distortion of the dichloro resin is 240 to 265 degrees, Fahrenheit, compared with 165 to 190 for polystyrene.

WELDING PLASTICS

By Using Hot Inert Gas

A NEW method of "flame" welding of plastics is described in recent reports from England. The torch heats an inert gas—nitrogen—to the proper temperature to soften the resin and then directs the stream of hot gas at the point to be softened for the weld. The problem of control of temperature has caused some concern but has been solved best by the skill of the worker rather than by intricate control devices. Results are reported to be excellent when an inert gas is used instead of flame or products of combustion directly.

PROTECTING CANS

By Dipping Them in Simple Alkaline Solution

THIS global war has imposed a severe and extraordinary burden on the tin coating of cans. Failure of the protecting coating has been frequent.

A new method of improving the effectiveness of the tin layer, made even thinner by war, consists of dipping the filled and completely processed cans into a hot alkaline solution. No satisfactory explanation of the remarkable effect of this simple, quick treatment has yet been found.

But the explanation is probably less important at the moment than the fact that cans so treated resist corrosion in humid, hot atmospheres substantially longer than untreated cans. The new protective method entails neither the complications nor the expense of lacquering, and it lends itself to mechanical application in the cannery.

Metals Make Railroads

The Railroads are Planning Now to Utilize the Far-Reaching Advances Made by Metals During the War in Higher-Speed, Lighter-Weight Rolling Stock for Both Passenger and Freight. With this Equipment They Will Meet Peace-Time Competition of the Airplane, Truck, and Bus

THE HISTORY of the railroad industry has been underwritten by the progress of the metal industries. The steel rail made possible the great expansion in railroad activity in the middle of the last century. Boiler plate made from open hearth steel provided the urgently needed solution to the problem of larger plates for the bigger locomotives being built. Steel axles permitted heavier loads.

To an even greater extent, however, are the futures of these two groups of industries interwoven, for the post-war period will be a critical one for the railroads. Informed engineering opinion among railroaders is virtually unanimous that only through extensive and thorough-going use of new high-strength or lightweight materials in the enormous car-building program projected can the railroads out-distance the expected competition from bus, truck, and airplane.

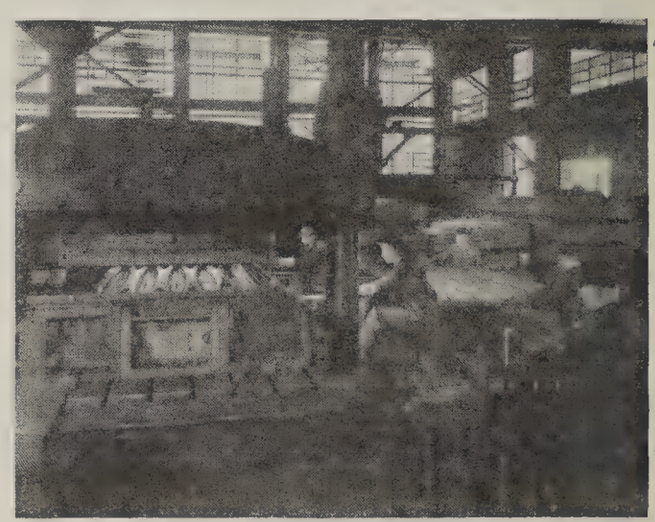
Plans are already underway for broad re-design embodying the most modern materials for lightweight construction. We may confidently predict many startling developments of this nature from the railroad industry in the early post-war years.

In its simplest terms, lightweight construction can mean either higher speed, less power consumption, or greater pay-load to the railroad. Any or all of these factors make railway transportation more competitive or more economical. The lightweight construction may be accomplished by using lightweight materials (such as aluminum alloys, magnesium alloys or plywood) or high-strength materials (for example, alloy steels, stainless steels or heat-treated carbon steels) and by employing fabricating methods like welding that are ideally adapted to this type of construction.

METALLURGY HELPS STREAMLINING—From the standpoint of the public, the most spectacular application of the lightweight development in the railroads has been in passenger cars—particularly in some of the streamlined high-speed trains. Here the goal has been a combination of speed, comfort, and beauty with adequate safety. The materials used were chiefly aluminum alloys, stainless steel, and low-alloy, high-strength steels. The last are a group of steels containing fractional percentages of chromium, phosphorous, copper, nickel, molybdenum, or others, with good mechanical properties, weldability and corrosion resistance. They are only slightly more expensive than plain carbon steels.

Originally lightweight passenger car construction was based on aluminum alloy (pioneered by Pullman-Standard) or on stainless steel (pioneered by Budd). The development of the much cheaper low-alloy steels provided a third and welcome medium that was put to use by practically all car builders in some form.

At the beginning of the war, when construction of passenger cars was discontinued, four structural types were being built—(1) all-aluminum-alloy, of riveted girder type side construction, lighter by several thousand pounds than any other, but more costly; (2) stainless steel, of truss-frame construction with spot-welded connections, and with the outside sheets functioning as covers rather than strength members; (3) low-alloy steel truss-frame, of all-welded construction, with sides covered with corrugated stainless steel, and weighing about the same as all-stainless cars of equivalent strength; and (4) welded-girder constructed throughout of low-alloy, high-strength steel, weighing only a trifle more than the truss-type car but less expensive.

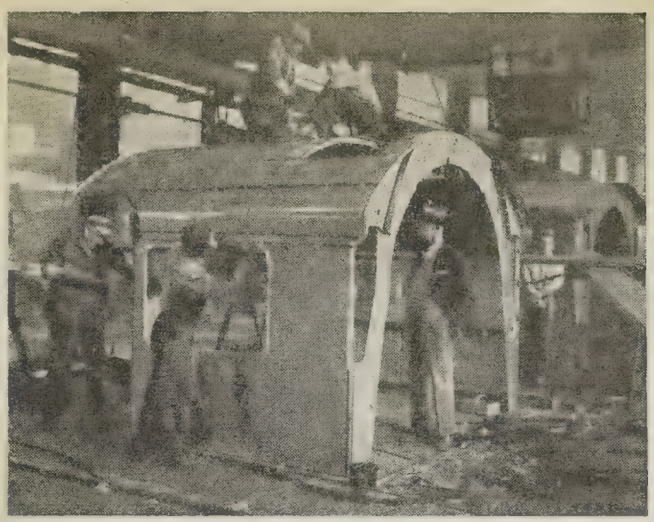


Right: Car-ends of low-alloy steel are being cold-flanged
Courtesy Inland Steel Company

Below: Low-alloy steel made by the Bethlehem Steel Company was used in building this lightweight day coach



LIGHTWEIGHT TRAINS POPULAR—At the present time there are some 120 lightweight streamlined passenger trains and hundreds of additional lightweight cars in use. A comprehensive and detailed analysis of their performance has shown that before the war they were distinctly profitable investments for the railroads and that during the war period, with all trains presumably loaded to



Left: Cabs of aluminum alloy being fabricated for use on high-speed steam locomotives

Courtesy Aluminum Company of America

Below: Workmen lowering into place the end section of an aluminum alloy railroad car



their doors, the lightweight trains show larger proportionate increases in traffic handled than the standard trains.

For this reason virtually every railroad plans to add streamlined lightweight trains to its lines, a survey made by a leading railway business magazine recently revealed. Railway executives' comments ran something like this: "The railways realize their present passenger equipment is outmoded and are planning to replace it with modern lightweight equipment just as soon as possible after the war". . . "The improved metallurgy coming out of this war will insure light weight with the utmost in comfort. . . I look for a tremendous improvement in the speeds with which railway trains are operated." . . . "We are so thoroughly convinced that comfort and speed are so important that at the end of the war we will proceed as rapidly as we can to replace all of our conventional equipment with modern cars."

The big question now is: "Which materials will participate most heavily in this enormous car-building program?" From 1935 through 1939 some 1458 passenger cars were built, of which 63 percent were of low-alloy steel, 20 percent of stainless, 11 percent of aluminum, and only 6 percent of conventional design using ordinary carbon steel. This may foreshadow the future trend.

However, weight is not the sole factor, although it is obviously the prime mover. The so-called "steel" coaches (they embodied considerable wood) of 1906 weighed 110,000 pounds. A typical all-steel coach of the late twenties weighed 130,500 pounds, but was longer and carried many more specialties. Modern de luxe cars weigh less than 120,000 pounds, despite a startling increase in the weight of specialties over the last 25 years. If the modern cars were to have specialties similar to those of 1906, we would find typical low-alloy steel cars weighing 113,000 pounds, aluminum-alloy cars weighing 105,000 pounds, and stainless-steel cars somewhere between.

This is a remarkable weight-saving accomplishment in car bodies, especially in view of an increase of some 10 feet in the length of typical cars of today over those of 1906. On the other hand, it also points a stern finger at one outstanding direction in which passenger car design can still be radically improved: the lightening in weight of the specialty items, which are following a trend opposite to that of the car bodies.

METALS WILL COMPETE—Only time will tell which of these three types of materials is best and cheapest for passenger car structures. The war has had the most pronounced effect on aluminum by enormously increasing its production capacity and by spreading the know-how of handling the material on a much broader scale than ever before. For extreme light weight and highest speed, aluminum cars are still the most popular.

Stainless-steel cars, on the other hand, have the most eye-appeal and their strength-weight ratios in the cold-rolled condition are outstanding. Furthermore, they require no painting or other protection. The low-alloy steel cars, finally, have good all-round properties, are the cheapest of this group and can be used as-rolled—that is, they do not require heat treatment as do the aluminum alloys nor must they be fabricated in the difficult cold-worked condition as must the stainless steels.

Magnesium alloys are generally admitted, even by their manufacturers, to have little possibility of early use in the structural members of railway cars. They can and will be used, however, for many non-structural applications, especially to lighten the weight of specialties.

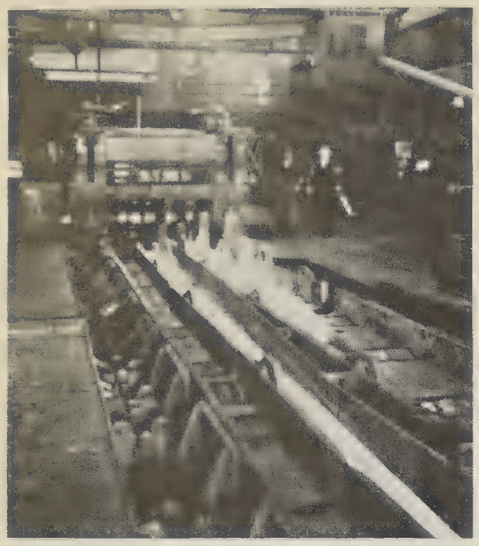
Of course all this ignores the possibility of new magnesium alloys with radically different properties than those now on the market, but none are as yet evident. At the same time, the aluminum industry *has* produced something which the railroad industry has yet to place in commercial use—new, super-strength aluminum alloys and clad materials with vastly improved strength-weight ratios—while a new low-alloy steel containing molybdenum (Aldecor) has just been announced.

IMPROVING FREIGHT CARS—But what about the more prosaic freight car? Here the competition is narrowed to exclude the expensive stainless steels from all but the most specialized consideration. It is stretched, however, to include copper-bearing open-hearth steel and steel castings (liquid-quenched and otherwise) as well as aluminum and low-alloy steel for lightweight construction. The choice is of considerable economic importance to the railroads. Every reduction in weight of one ton represents an operating saving of $15 per year to a road. Hence, a typical reduction of 10,000 pounds in a single car means $75 per year. In terms of increased payload, a reduction of three tons per car is reported to result in 5 to 7 percent greater payload regularly.

The popular material to date seems to be open-hearth steel containing a small amount of copper. The low-alloy steels are nevertheless currently receiving extremely favorable attention from designers and prospective purchasers of post-war freight cars, because for many applications their cost is so much less than for a car of the same weight made of aluminum. Actually, in nature and cost, they are much closer to the ordinary open-hearth steels than to the aluminum alloys, yet their weight-saving possibilities are substantial. Many alert car builders consider them a more economical solution to the lightweight problem than the copper-bearing steel mentioned earlier.

The seriousness with which the railroad industry regards this matter is well indicated by the recent order placed by the Missouri Pacific Railroad for 25 aluminum alloy 70-ton hopper cars to be made by American Car and Foundry Company—said to be the first order of its kind ever placed. The entire bodies will be of aluminum alloy with the center sills and bolsters of steel. The cars, when empty, will weigh about 38,000 pounds each, contrasted with an average weight of 50,100 pounds for the conventional steel 70-ton hopper car, or about six tons less for the locomotive to pull. They will have 240 cubic feet greater carrying capacity. The railroad intends to study closely the performance of these cars to determine whether their higher cost is sufficiently counterbalanced by the resulting improvement in net operating revenue from them.

CHEAPER METALS SUGGESTED—Two other means of achieving weight saving in freight car construction without adopting highly expensive materials have recently been suggested by outstanding metallurgists. One is that the railroads attempt to utilize quenched-and-tempered plain carbon or low-alloy hardenable steels for structural members, based on the experience of the automotive and aircraft industries



To avoid transverse fissures in steel rails, careful control of temperatures is required while the stock is rolled

that "heat treatment is the cheapest practice metallurgy has to offer for increasing the strength of steel without too great a sacrifice of ductility."

The other suggestion was that the railroads determine for how many important applications they might not profitably forego their present practice of specifying a more expensive, completely deoxidized, fine-grained, non-aging steel, and (where no corrosive service is involved) use instead a semi-killed steel with just enough carbon and the cheaper alloys to raise the strength to the proper level and still keep the steel cheap.

By regulating the rolling mill practice, it is often possible to secure improved structures to meet the requirements. Not yet tried by the railroads, this approach has been highly successful in other applications, in one of which it has been in regular large-scale use for several years.

BETTER LOCOMOTIVES—In the case of the locomotive, side and drive rods are under continual study to reduce their weight or increase their ability to resist stress. Here again the answer would seem to lie in the heat treatment of the parts to get the most benefit from their alloy content. New high temperature alloys have improved the performance of locomotive boiler systems, which in the post-war period will therefore operate at higher temperatures and pressures than formerly.

In this respect a most significant development is the emergence of the gas turbine as a potentially important railway prime mover. Engineers are agreed that the gas turbine will certainly become of interest as a locomotive drive when alloys of sufficient heat resistance to match the temperatures required for most efficient operation become generally available.

Many other materials find important and changing use in our heavily loaded railroad systems. Copper and its alloys serve to the extent of more than a billion pounds in permanent use, primarily in the conductor wires for electrical railways, signal systems, headlights, and so on. In addition, they are important constituents of railway train air-conditioning systems which are expected to be universally installed in post-war trains. Brasses and bronzes, lead, tin, and their alloys are widely used for bearings, while all types of solders and brazing alloys find substantial application in locomotive construction and in the assembly of general electrical systems as well as decorative items and other specialties.

Steel castings are among the most important of railway car materials, being used for bolsters, side frames, couplers, and so on. Axles have received a great deal of attention lately. A general effort is underway to reduce their weight by various means, among them heat treatment and the development of a hot-pierced, hollow steel axle. As to wheels, chilled iron wheels have been traditional for freight cars, but steel wheels are receiving increased application as the speed of freight traffic increases.

The best possible closing for this article is provided by S. L. Hoyt and H. W. Gillett of Battelle Memorial Institute, who said in a recent paper before the American Society of Mechanical Engineers: "It seems clear that we have entered a new era, that of high speed traffic. . . A corollary of high speed is low weight. . . Recourse must be had to new materials which are either inherently stronger or which have a more favorable strength-weight ratio than the old. Insofar as high speeds affect fabrication or construction, the outstanding feature of recent years has been the swing to welding to save weight and increase the joint efficiency. . . It is the hope of all that the new materials and the new methods of shaping, joining, and fabrication will provide needed answers to many railroad problems."

The most progressive railroad men are certain that they will!

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HIGH-SPEED MILLING

With Carbide Tools and Negative Rake Angles

New machining developments of recent years have been as spectacular in their production and cost benefits as the new and increasingly used practice of milling steel at very high speeds with carbide tools and negative rake angles. Higher production, better finish, and lowered heat-distortion are the outstanding advantages—in some instances production increases of several hundred percent over ordinary milling practice using tool steel cutters have been recorded.

Originally a West Coast aircraft industry development, the practice is spreading fast to alert shops throughout the country. The accompanying illustration shows graphically the difference between conventional milling and negative rake angle practice.

Actually, the inner edge of the cutter is ahead of the outer edge. The action has been likened by a North American Aviation engineer to a stroke of the hand in the sand. If the forward stroke is by the finger tips of the hand (positive rake) they dig into the sand; but if the forward stroke is accomplished by the heel of the hand (negative rake) the bite into the sand is a drag, the line of force flowing back through the wrist and arm to be absorbed by the shoulder joint.

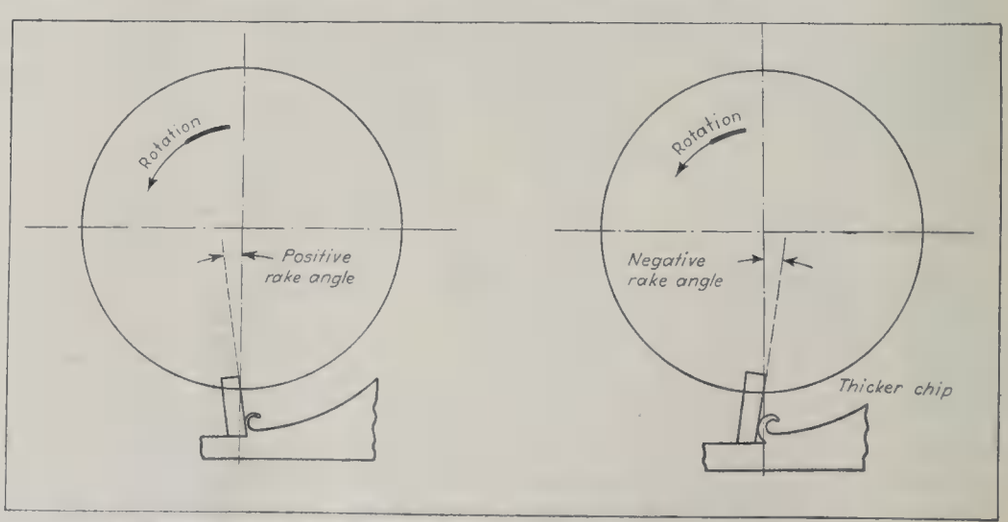
ELECTROGALVANIZING

Provides Protective Zinc Coatings on Steel

A notable trend in the applications of metals and metal coatings is the growing interest in and use of electrogalvanizing as a method of producing relatively thin but adequately protective zinc coatings on steel.

Using the same electrolytic lines that have revolutionized production of tin plate, there are now 26 units in the United States capable of turning out electrolytic zinc-coated sheets. High purity zinc is being deposited on continuous strip up to 38 inches in width, at a speed of 160 feet per minute, in coating weights up to 0.2 ounces of zinc on both sides, per square foot of strip

This development offers many possibilities in the expansion of the use of pre-plated metals, and the automotive industry is giving serious consideration to the possible use of such zinc-coated steel for body stock. Consideration is also being given to the use of small stampings made from zinc-coated steel, where the protection of zinc is carried over to the cut, unplated edges through galvanic action.



Many milling advantages stem from the use of negative rake angles

Wheels Of Worth

In the Mutual Working Relations of Railway Car Wheels Rolling on Steel Rails There are Some Interesting Applications of Fundamental Science. An Abbreviated Consideration of the Effects of Heavy Stresses and Strains on Both Wheels and Rails. How Much Wheel Area Touches the Rail?

By L. K. SILLCOX
First Vice President, The New York Air Brake Company

OF THE WHOLE SUBJECT of railroading, perhaps the least likely phase to hold the public attention is that of the relationship of wheels and rails. Though romance favors "The Iron Horse"; though the public taste leans toward more luxurious lounge and bar cars; and though safety in the form of refined signal and communication systems meets a proper public insistence, down under the comfortable train on which you ride there is something basic to all these—the homely, commonplace, but all-important wheel-and-track combination.

In the accompanying article the author has condensed some of the fundamental meat of a wheel-and-track science about whose extent not all of us are very conscious. Have you ever wondered how the wheels of a railway car withstand the rampant stresses to which they are heavily subjected? How the rails resist the action of the wheels? What mechanical considerations surround an apparently simple a question as how a train stays on the track? After reading this article you will be likely to watch and study the wheels you see rolling on rails, and will be made more conscious of how the railroads maintain their splendid safety and service.

The author of this article is the author of a book, "Mastering Momentum," a study of railway equipment and its operation.

—The Editor

ORIGINALLY railway car wheels were made of wood and were run on wooden rails. As at present, a flange on the side of the rim served to guide the wheel but, later, flanges were placed on the rail in order that wagon wheels could be operated on them. Eventually the flanged wheel was found to be the more satisfactory, and the guiding action was returned to the wheel.

The wooden wheel was discarded about 1767, and many designs were experimented with before the present types were universally agreed upon. These are the chilled-iron wheel, the cast-steel design, and those of wrought-steel, both single and multiple-wear.

In 1789 the process of chilling iron was developed, but the first chilled-iron wheels did not appear until about 1816; and by 1867 this wheel design had been quite generally accepted for freight car use.

By 1865 steel was becoming important as a metal in wheel design, steel tired wheels being installed under passenger cars in this country and under both freight and passenger cars in England.

The next development in the evolution of the car wheel was the one-piece wrought-steel type, experiments beginning in 1900 and the first major installation being made in 1906. This design is very similar to that known as the multiple-wear steel wheel of today, in which the tread is thick enough to permit turning down after wear; although in some instances the present-day wheel is heat treated by quenching and tempering to harden the tread and flange, thereby reducing the rate of wear. The wrought-steel wheel is initially formed into rough shape by forging under a press with the plate part of the wheel straight. In a further operation the plate part is coned or dished by pressing into its final form.

About 1926 the one-wear wrought-steel wheel, with a reduced plate and web thickness, was introduced. The only other difference from the multiple-wear design was a reduction of the tread thickness, making it impossible to restore normal contour by turning down. Prior to this innovation, in 1903, cast-steel wheels had been introduced into service on a test basis, the first installation in this country being in 1911. This wheel is cast in a mold fitted with metal chillers around its outer circumference. It is heat treated after it is cast.

A relatively recent addition to wheel design is the spun-steel design. In the manufacture of this wheel a special steel is poured into a mold revolving at high speed. Subsequently it is heat treated also.

WHEEL AND RAIL DEFECTS—In load support and in guiding along the rails, wheels and rails receive identical stresses. A wheel and a rail have much in common, even as to form. Each has a substantial contacting mass to receive traction abrasion. In the wheel, the rim is supported by a broad area, the hub, and similarly in the rail, the head is supported by a broad area, the rail base. The hub and rim of the wheel are connected by a relatively light member, and so are the head and base of the rail. The contacting areas are termed the wheel tread and the rail running surface.

Wheel tread defects also have their counterparts in defects in the running surface of rails. Wheel rims and rail heads fail by local distress, or loss of metal, and by transverse breakage. The breakage of rail webs from lateral stress sometimes occurs corresponding with the collapse of plates of wheels under torsion from heavy traction couples, oft-repeated and quickly applied and reversed.

The sliding of a wheel without rotation has an effect upon the tread that is very similar to the effect upon the rail of slippage of traction wheels without forward motion. In the first case, a single point in the wheel periphery engages a rail running surface which constantly presents a new contact. In the other case, when traction wheels slip, a single point on the rail is acted upon by a renewing wheel contact. In either case, energy dissipation is concentrated over an extremely limited area of one surface, high temperature results, structure of the metal is affected, and a loss of metal may occur beyond the abrasive effect. Reactions upon wheels may be equalled by reactions on the rails upon which they bear, but they are vastly more repetitive on the wheels.

SHELLED WHEELS, RAIL BURNS—In so far as failures of wheels under load are concerned, two effects are predominant. In the first, vertical pressures between wheel and rail introduce shearing stresses which frequently approach allowable working loads for the materials ordinarily employed—even when subjected to the most favorable operating conditions. Tensile and shearing resistance of carbon steel decreases materially at elevated temperatures and there are two factors, met in normal railway operation, which create sufficiently high local temperatures to weaken appreciably the resistance of the material. Their effects are obvious. When a non-rotating wheel slides, a temperature of 800 degrees, Fahrenheit, or more, is momentarily developed at

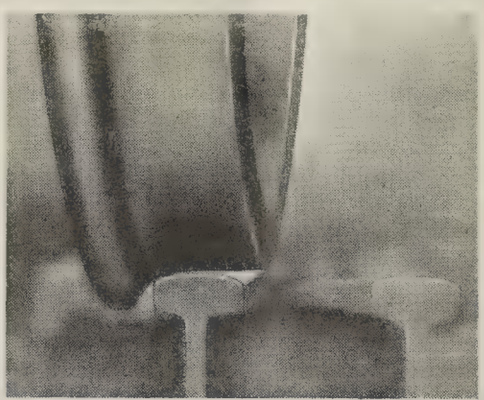
one point in the tread of the wheel and the strength of the material may be reduced as much as 40 percent. Should the ultimate resistance be exceeded under these conditions, a section of the metal breaks away and may be dislodged long after the overheating and stressing occur, or evidence of them is removed. When wheel metal is lost in this manner the visible defect is termed a "shelled" spot. A rail "burn," which has the same appearance as a shelled spot in a wheel tread, results from identical conditions—a railway wheel, rotating for an appreciable time but bearing upon one point on the rail, weakens the metal, produces fracture along natural slip planes, and the metal subsequently separates.

In the second effect of loaded wheel failure, high tread temperatures, extending completely around the periphery of a railway wheel, may result from prolonged braking at high pressure and speed. Under these conditions, as with soft wheel treads, shelling is aggravated, and wheel metal is reduced to a state where flow occurs—a pressing of the metal away from the bearing zone until it projects beyond the edge of the wheel rim. This has proved very troublesome where interference with closely fitting parts of the brake mechanism has been experienced. Ordinarily, only loads exceeding 25,000 pounds per wheel produce this defect, and the greatest difficulty is experienced with locomotive tenders because wheel loadings in other services are usually not excessive.

WHEEL LOADING—The pressure with which cast-iron brake shoes must be applied to wheel treads to produce a given braking rate increases somewhat faster than in direct proportion with the total weight supported. Very high speed operation demands still higher brake shoe pressures and extends both the time and distance over which this pressure must be sustained. Despite a somewhat variable coefficient of brake-shoe friction, the pressure is a direct measure of the energy input, represented by heat, which wheels and brake shoes must receive during braking. In this way, weight again must take indirect responsibility for wheel damage — in some cases evidenced by characteristic shelling when loading is extremely heavy, and at other times by thermal checking under more moderate bearing pressures.

THERMAL CHECKS—A thermal check is a hairline crack extending across the wheel tread and is the result of a difference in the rate of expansion between a very thin surface layer and the underlying metal. Exposed to abrasion by the brake shoe, which reaches local temperatures as high as 2500 degrees, Fahrenheit, in extreme cases, a thin ribbon of wheel tread metal receives tremendous local energy (heat) accumulations at so rapid a rate that a high temperature difference is set up between the tread and the body of the rim. The resulting difference in expansion, together with the change in physical structure of the surface metal, results in these tread cracks. A zone develops which encourages and, at the same time, is highly susceptible to stress concentration. High local stress, fatigue conditions, and impact effects combine to increase the crack and if it is permitted to extend it may cause a complete fracture of the wheel, extending from the defect on the tread all the way to the hub. This is a reason for the substitution of a steel-tired wheel for the all-steel design in extreme cold climates. Here, while the wheel tread temperature is elevated during braking to a degree comparable to that experienced in warmer territories, the hub remains much cooler, with a resulting intolerable temperature gradient for solid wheels.

The service of railway car wheels has become progressively more exacting without corresponding study being accorded to the capacity of wheels and rails to withstand the requirements of the service and difficulties to be met. Yet, because of many practical and structural limitations, it has not been possible for railways to compensate by employing larger wheels or enlarging the running contact with the rail by adopting broader rail heads. There are instances where a greater number of wheels could be applied to advantage, relieving the demands per individual wheel, reducing wheel maintenance cost, improving equipment utilization, and affording insurance against service failure, but such an expedient increases initial cost and adds to weight.



The bearing is at a theoretical point, enlarged by metal yielding

In most cases, railways have preferred to suffer necessary maintenance expense, and to depend upon rigid inspection for security from accident. The records show their service to be outstandingly safe but with a cost penalty suffered in many instances, an element that is being improved as materials research progresses.

LATERAL LOADING — Thrust loads—which in railway terminology means the side pressure exerted by the wheel flange upon the rail head—are inescapable but must, in the interest of comfort and safety, be maintained below certain specified maxima. The magnitude of thrust loading at wheel flanges is judged only by lateral impacts transmitted to car bodies and recognized in resulting riding qualities. Inasmuch as the flange guides the trucks along the rail "highway," excessive flange wear is sometimes taken to be a measure of that service performed, but more often it is an indication of questionable equipment maintenance. Lateral loads on railway wheels introduce definite and severe bending moments within the wheels. These are relieved by yielding lateral restraint through swing hanger and spring devices, but they reach high values. The fact that wrought-steel railway wheels have been successfully continued in services many times more severe than those in which they were heretofore required to operate, yet still have offered a high degree of security against service failure, is indicative of the measure of safe performance which was originally incorporated in the design.

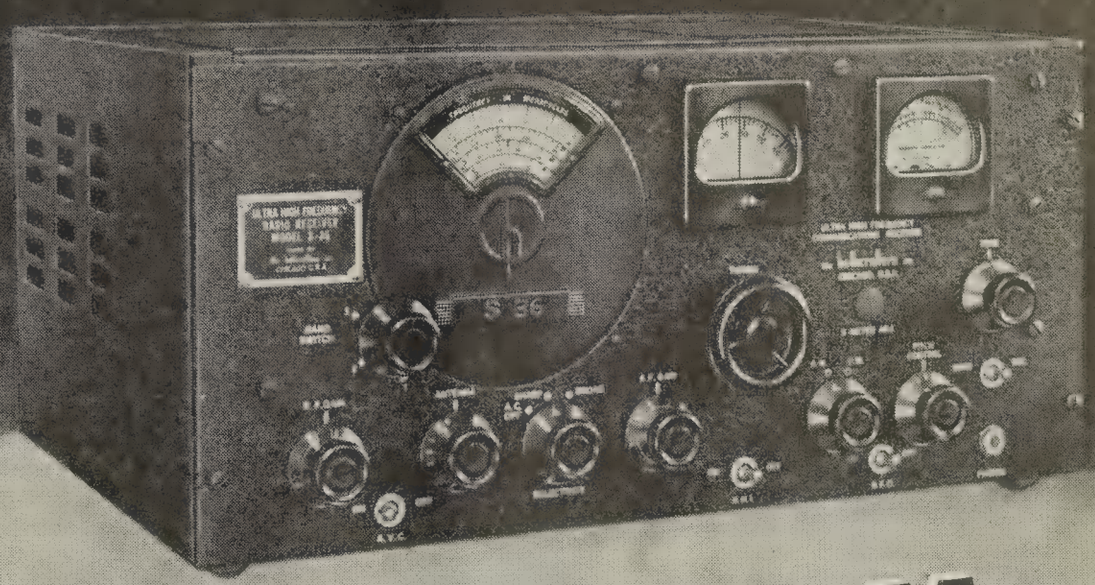
MATERIAL SELECTION—Not far in the past the heaviest wheel loading generally practiced, plus the most severe heating effects experienced in braking, did not tax the capacity of wheel and brakeshoe materials or involve the railways in unusual maintenance expense. As long as this was true, there was little incentive seriously to investigate the possibilities of alloy substitutes for wheel materials or the potential advantages to be secured by carefully controlled heat treating. All this has changed. Molybdenum is now an ingredient in many railway car wheels used in exacting service; and the low carbon wheel, resistant to the origin of thermal cracks, is being made more suitable by precise heat treatment, carefully carried out.

INTERNAL EFFECTS — Under vertical loading, intense shearing stresses are delivered simultaneously to wheel rim and rail-head metal in contact, subjecting them to crushing strains, compacting the material, cold working the structure, and altering their physical properties. A chilled-iron or wrought-steel wheel of standard tread contour bears upon a new rail head surface, or one worn in the customary manner, over a limited area of contact. This is illustrated in an accompanying photograph in which a portion of the wheel is shown on a rail section. Although the contact area theoretically is a point, that degree of perfection is never attained in practice. As the wheel tread becomes worn, its contour, starting with the standard taper of 1 part in 20, becomes more nearly cylindrical; in which case the point of contact is in fact not a point, but a line.

The wearing of the rail head also has its effect in developing this condition. Add to the effect of wear, the strains arising from wheel loading, and the actual point of contact becomes an area, its size being governed by the physical characteristics of the contacting metals and the loading imposed. In the case of a 33-inch diameter wheel, bearing upon a new 100-pound rail, the initial contact area under 30,000 pounds load will be approximately circular in shape with a diameter of $\frac{5}{8}$ inch. The measured area under this condition is approximately 0.30 square inch — a unit loading equivalent of 100,000 pounds per square inch. Surface wheel metal compresses under such conditions, and vertical flow within the metal has been measured at a depth of $\frac{3}{8}$ inch. The separation of wheel tread metal is im-

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minent and the shelling out of the wheel surface is to be expected under such circumstances.

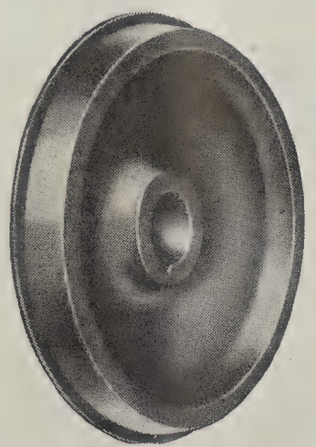
At the same time, flow in the rail head occurs. At 25,000 pounds wheel load, some compression with actual deformation occurs at a depth of ¼ inch. At 15,000 and 20,000 pounds wheel loads, no deformation can be measured at ¼ inch depth but, whatever the load may be within the range of common installations, a ribbon of surface metal is affected and repeated use under light load prepares both rail and wheel by cold rolling to receive heavier loading without damage. Just as a stiff rail distributes an individual wheel load over a distance embracing a number of ties, rather than transmitting the whole pressure to the tie or ties immediately below the point of wheel-rail contact, so, in the rail, the effect of the cold-rolled surface is similarly to distribute the load throughout the rail head. The rail deformation previously referred to in connection with the wheel does not exist in a rail which has a cold-rolled and consequently hardened surface, in a degree comparable to a more yielding surface. Hence, loading stresses are distributed over a longer section of rail head. A similar effect must be obtained in the tread of a wrought-steel wheel if the initial loading can be lightened, permitting the tread surface to roll to a suitable finish without overstressing the metal before applying the highest load that it will be required to sustain.

WHEEL-RAIL CONTACT AREA — As the diameter of a wheel is increased for a given wheel loading, the area of wheel-rail contact increases, and unit loading is decreased. In any case, the area of contact increases with service as both wheel tread and rail head contours adjust themselves to the average condition. Moreover, contact areas increase proportionately with the magnitude of the load, indenting both supporting surfaces and tending toward the automatic accommodation of whatever stress may be applied. It has been found that the load supported by locomotive driving wheels of 79-inch diameter is distributed over the measured area of contact with surprising uniformity. These are wrought-steel tires. On the other hand, the load carried by new 33-inch chilled-iron wheels is sharply concentrated at the center of contact. The distinction relates to the size of the two wheels under consideration, and not to the material of which they are composed.

While initial contact areas are of substantially circular configuration, the areas gradually assume elliptic formations with continued wear of wheel and rail. Actual intensity of maximum pressure in the rail head is greater beneath 33-inch, chilled-iron car wheels with customary loading than beneath the heavily loaded driving wheels of 63-inch diameter and over. In either case it can be shown that, because of vertical pressures alone, and with selection of unit wheel loads of the order commonly used, excessive stresses frequently are experienced. By virtue of the nature and direction of this type of loading, it is received and its reactions are set up without danger in any but most extreme cases, and without involving sufficiently great maintenance expense to demand correction.

Were forces of like order delivered laterally, operation would be unsafe, since guiding along the rails would be seriously affected by excessive flange pressure against the rail head. Furthermore, this force would have a tendency to loosen the rail from its fastenings and, in extreme instances, the rail could be overturned.

LATERAL STRESS IN RAILS — Lateral stresses in rails, delivered at the rail head and loading the rail section at a distance above its supporting ties equal to rail height, arise from the position of the wheel on the rail head, as determined by wear of the contacting areas; from the lateral sliding of wheels on rails permitted by the necessary clearance between rail and flange; from the inclined installation (canting) of rails practiced by some railways to secure more liberal wheel-rail contact area when new wheel treads are given an initial taper; and from the guiding of wheel flanges on curves. The gradual super-elevation of the outer rail on straight track approaching curves establishes a type of lateral loading identical with that resulting from a canted rail. The amount of super-elevation of the outer rail on curves is established for a single speed and, if the actual operating speed is either higher or lower than the ideal, a similar lateral loading will result. If the speed is too low the reaction is against the inner rail and, if too high, against the outer rail.



The wheel, an invention on which our modern civilization is based

WHEEL TREAD TAPER — The standard taper of 1 in 20 to which car wheels are formed introduces a lateral component of negligible amount which presses each rail in an outward direction. Since this component and actual flange pressure cannot occur simultaneously, the effect of tread taper upon rail stresses need not be considered. Tread taper is furnished to provide a centering tendency of the wheels on the rails. To be most effective, a much steeper taper would be required and this in turn would increase lateral pressure proportionately — a condition which, though undesirable, would be evidence that the centering function was being served.

When the matter of unbalanced wheels is treated, the natural reaction is to think of the locomotive drivers but, surprisingly, road tests conducted for the purpose of checking the magnitude of rail stress arising from driving wheel unbalance have disclosed that even higher dynamic blows may be struck by the wheels of heavily loaded tenders and freight cars. Not only is the rail stress increased markedly, but there is a tendency for the wheels to run hot. Furthermore, a rail surface condition, termed rail corrugation, may result from the intensified rail pressures induced by the passage of unbalanced wheels at high speeds. The result is a noisy rail which is sometimes referred to as "roaring" or "washboard" track. The rail, its fastenings, and supporting structure are damaged, as is the equipment which moves over it. There are various minor causes for corrugation, but there is one basic condition which must be initiated if the phenomenon is to develop: synchronized vibration with an accompanying overstressing of the rail metal. Both rolling stock and track structure have definite periods of frequency of vibration, and if those frequencies synchronize, corrugation will result. Add to that the increased stress caused by unbalance and the condition is aggravated.

SIGHT AND SOUND—In the past, when car inspectors with hammers came out and tapped wheels on passing trains during terminal stops, their ability to discover defective wheels and axles, as well as wheels loose on axles, became truly remarkable after experience. They depended entirely on the sound emitted. The more recent change from the "sound" to the "visual" method of inspecting railway wheels and axles brings into clear distinction the differences in the technique involved to reach a similar goal.

The later system did away with the reassuring sound of the inspector's effort and substituted one where sight and silence alone are depended upon. Elaborate means have been worked out to make this system work by employing depressed pits fitted with mirrors (no doubt a forerunner of an "electric eye" technique) where trained men with the most expert vision are stationed to discover defects in passing trains. The skill and the alertness of the crews assigned to this work are demonstrated every day by subsequent inspection of the units of equipment they have thus marked out for repairs and which might otherwise have caused a bad wreck.

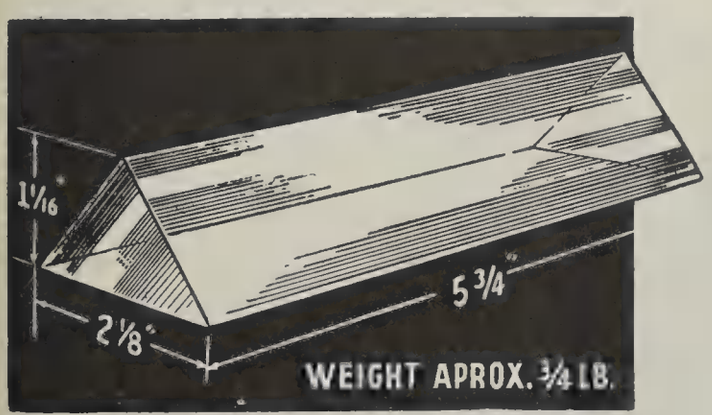
However, the method of tapping wheels, or inspection by sound rather than vision, is still followed by some of our more northerly situated railways. The cold climate creates a higher heat gradient, or difference in temperature between parts of the wheel, and thus increases the chance that wheel defects may develop. Also, the presence of snow and ice make visual inspection less reliable. Therefore the greatest precautions must be practiced in order to safeguard properly the equipment and its integrity of movement.

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6020-S	18	49	Uncemented	50¢
6021-S	18	49	Cemented	60¢
6022-S	25	95	Uncemented	50¢
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Luxury On Rails

In the Coming Post-War Scramble for Passenger Business, the Railroads Will Have Much to Offer. Pullmans Will Feature Private Rooms More Than Before, and New, Low-Priced Three-Tier Sleepers Will be Introduced. Moving Pictures and Dance Music Will Entertain Travelers

By HARRY E. SCHADEN

IN THE early 1930's the railroads of America were jolted into wakefulness by the growing competition of the auto, the bus, and the airplane. To hold their own, they introduced air-conditioned, streamlined, smooth-rolling trains which made travel by rail a pleasure even for coach passengers.

Now the railroads are ready for another period of advances. On their behalf, the nation's carbuilders have in preparation a series of innovations that will make their passengers comfortable both day and night, whether they are on a coast-to-coast journey or a short ride into the suburbs.

All the improvements planned are a legacy of years of drawing-board work and laboratory experimentation. Neither railroad executives nor equipment manufacturers are given to radical changes that may be founded on whimsy. When one considers that the average modern lightweight passenger car costs $80,000, it is easy to understand why engineers do not toy with car designs as a milliner does with hat styles.

In order to get a down-to-earth view of what the railroads want in the way of improvements, Pullman-Standard Car Manufacturing Company made an intensive survey more than a year ago. The company interviewed executives of 71 railroads owning 92 percent of the nation's passenger cars. The survey showed that the railroads, regarded by many as ultra-conservative, had gone modern-minded to an astonishing degree. Most of the officials interviewed said they wanted more color in trains, newer and faster streamliners, more recreational facilities, improved baggage handling systems, better lighting, and bigger and better washrooms. In brief, they asked for modern trains.

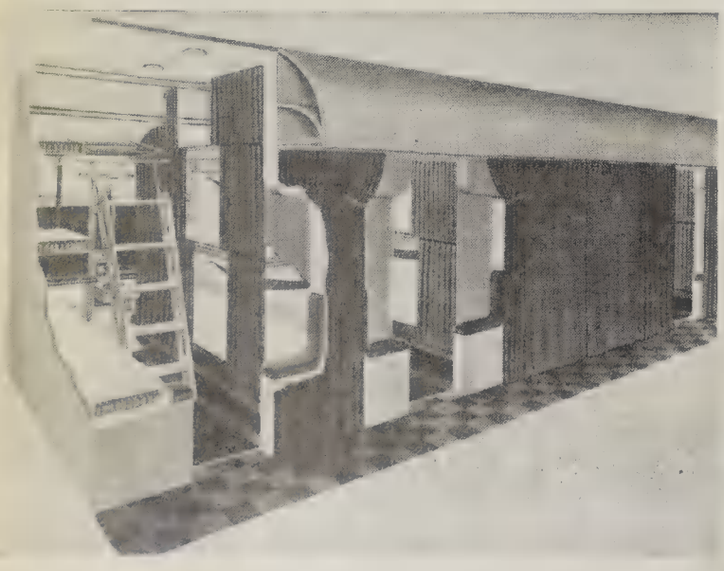


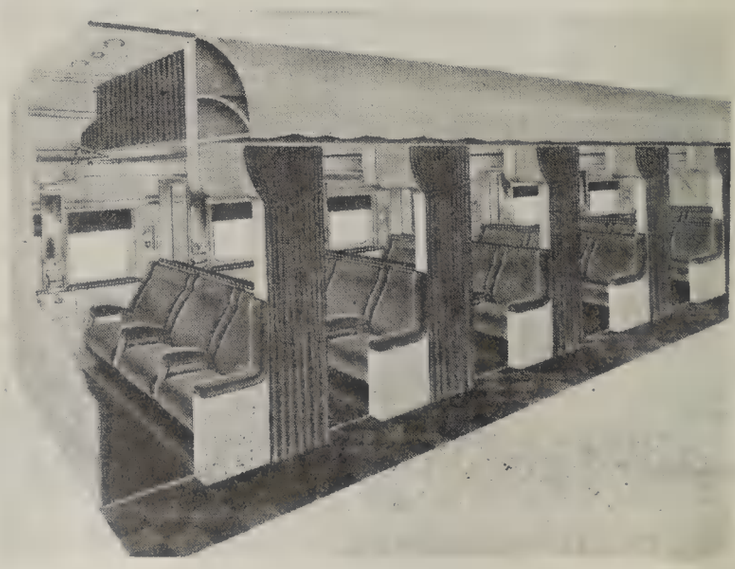
Above: Solid comfort in the three-tier sleeper the railroads plan to introduce for lower-income travelers. Lower right: During the day the new sleeper will be divided into seats set three in a row across the car. Lower left: At night the car will be made up so that each triple tier of berths will divide into a section

Some carbuilders already had anticipated this trend and had plans for these kinds of improvements on their drawing boards before the beginning of World War II. One of the most interesting of the new developments is progress in private room design. In recent years there has been a marked trend in this direction as passengers became acquainted with the extra comfort that private rooms afford at little added cost.

TWO-STORY PULLMANS—Even the cost margin is reduced to a narrower point in the new duplex roomette car, which is expected to become one of the most popular accommodations. Engineers, by using an ingenious staggering principle of design, have put 24 private rooms into the same space which earlier contained only 18 roomettes of conventional design. The rooms are arranged on each side of a center aisle, with the lower room at aisle level and the upper one reached by two steps.

The duplex roomette is an achievement in space conservation. Within its walls it contains most of the functional fixtures of a bedroom, living room, and dressing room. Each roomette has individual control of heat, light, and air conditioning, complete toilet facilities, electric shaving outlet, a large mirror, vacuum bottle for drinking water, and

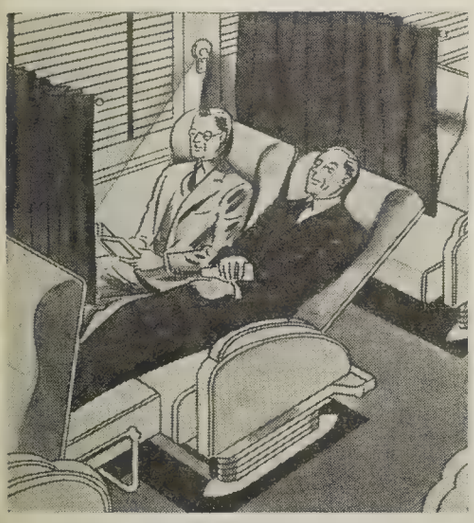




a bed that is six feet, five inches long.

The bed in the lower room, when not in use, slides under the floor of the upper room. The upper room bed is a fold-in-the-wall type which may be operated easily by the passenger. Beds are made up before the train leaves the station and the traveler can retire at any time without summoning the porter.

A CHEAPER SLEEPER—Comfort of the lower budget traveler is just as important to railroads as that of the man



In this new day and night coach, leg rests pull out of the seat ahead to give a full-length sleeping surface

who has unlimited funds. So this problem has been solved by designing a new car called the three-tier sleeper. Of entirely new design, it has more than 40 berths, compared with 28 in the average old type car. In the daytime it is an attractive coach. Seats are all on one side, somewhat in the European fashion. At night, the car is converted into a sleeper, with each triple tier of berths forming a section. Each section has its own lavatory facilities with additional washrooms at each end of the car.

That takes care of the situation for the traveler who desires a berth. But engineers have also kept in mind the day and night comfort of the passenger who takes cross-country trips in a coach type car.

One of the principal objections to coach travel in the past was that it afforded doubtful comfort at night. Passengers did not rest well because they were unable to get their feet up level with their bodies; hence their ankles and legs were likely to swell. To eliminate this discomfort, Pullman-Standard engineers designed a leg rest that pulls out of the seat ahead. It fits snugly against the seat and the occupant can recline as though he were on a chaise longe. Semi-privacy is afforded by window draperies which may be converted at night into curtains separating each pair of seats. Spot-type lights enable a passenger to read without disturbing other persons.

THREE-DECKER COACHES—Trains of tomorrow will include another innovation—the three-decker coach. Again engineering skill has shown its hand in the utilization of every cranny of space. The car is built on three levels so that it can carry 112 passengers instead of the 70 to 76 in the usual car. It has two washrooms at each end, plus provisions for air conditioning. As a favor to bridge players, the car has two card nooks, complete with tables. Luggage compartments take care of baggage that heretofore has cluttered up aisles.

When the engineers turned their attention to the dining car, again they had comfort and efficiency in mind. The problem posed in this instance was how to eliminate congestion in the aisles and at tables and reduce noise and confusion. Most of this was achieved by rearranging the seating plan.

It was learned that, by placing the tables diagonally, service was accelerated and interruptions caused by arrivals and departures reduced to a minimum. The arrangement permits waiters to step between tables when serving, eliminating congestion in the aisle. Other innovations include vibrationless tables, spot-ray illumination, linen storage at each table and intercar telephone communication. Shelves along the wall hold water bottles, creamers, and sugar bowls.

FUN FOR TRAVELERS—In the belief that a passenger's holiday should begin the moment he steps on a train, a recreation-lounge car has been designed. In the middle is a bar, a powder room, and a small compartment housing a motion picture projector which flashes newsreels and short subjects on the rear



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The roomy interior arrangements of the new three-decker commuter coach

of a screen facing the back half of the car. Chairs and divans arranged on each side of the car by day, swing on pivots into the aisle at night and face the screen, so that this section of the car becomes a small movie theater.

At the other end of the car, facing the bar, padded seats fold up against the wall at night, leaving space for a dance floor as large as that of an average night club. A phonograph record player in the movie projection room provides music.

These improvements probably will be the most effective sales argument the railroads will have in making their bid for future business, but new "hidden" mechanical devices also will do much to add to riding comfort. For example, one car manufacturer has developed a new kind of truck to provide a cushioned ride and a new hot-box alarm to increase safety. Other developments include a new high speed, electrically activated brake and a new lock coupler, both of which will reduce jerking and jolting when a train starts.

When will these new devices be put in use? Carbuilders today are concerned primarily with the job of producing their share of war materials and rail equipment essential to victory. Many factors must be weighed in determining when they will get the green light for their new products.

The important point is, however, that when the time does arrive for railroads to begin replacing their worn-out equipment, manufacturers will be prepared to open the throttle and start production of cars with improvements which they know will give the railroads a fair start in the coming battle for transportation business. And it all means that the public will get the best bargains it has ever had in travel comfort.

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RADIOSONDE

Advances Knowledge of The Upper Air

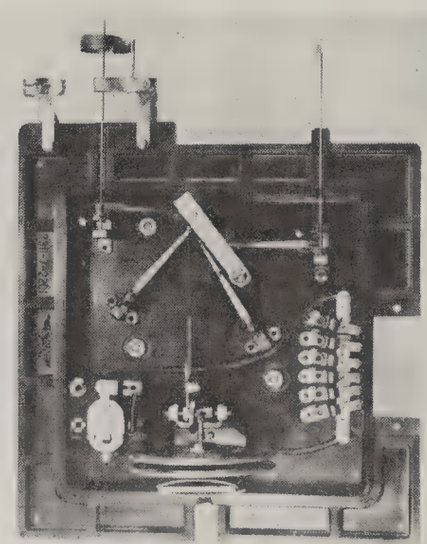
THE TECHNIQUE for exploring the upper atmosphere has been advanced greatly by the Chronometric Radiosonde Meteorograph of Simmonds Aerocessories. The unit comprises a "shoebox" which goes up by balloon and descends by parachute for safety. An alternative and perhaps more striking name for the new device is "The Weather Broadcaster." The average limit of ascension is between 50,000 and 60,000 feet, the range of flight may be many miles, and the length of flight from one to three hours. When the balloon breaks, the flight instrument floats to earth suspended from its 'chute, and bears a note offering a nominal reward for its return. The number of radiosondes returned depends upon the location of the flight and the ruggedness of the territory in which the landing is made.

The Chronometric Radiosonde Meteorograph contains three weather "feelers" sensitive to changes in temperature, humidity, and atmospheric pressure. A simple alarm clock mechanism keeps a recording helix continuously revolving. The radiosonde also carries a miniature high-frequency radio transmitting set consisting of a single tube and an ordinary meteorological battery. The whole is carried aloft by a five-foot latex balloon.

A bi-metallic thermometer is used to register temperature changes; changes in humidity are registered by the hygrometer which consists of a single human hair; a two-stack aneroid capsule registers changes in atmospheric pressure.

There are five styli—three movable according to changes in temperature, humidity, and pressure. The three weather styli move up and down the helix as they are moved by the hygrometer, the thermometer, and the aneroid capsule. Signals are made by electric contacts of the styli with a spiral wire on the helix. The timing of the signals from the three movable styli is measured in reference to those from the two stationary styli, or so-called reference styli. The instrument is completed by the transmitter which sends signals to the recorder on the ground.

A recorded chart comes out of the recording apparatus where it is spread over a drum, around which is wound a raised wire corresponding exactly with the helix in the meteorograph aloft. The paper passes under a sheet of carbon paper and a steel bar. This bar is tripped every time a signal is received. Since the drum in the recorder on the ground and the contact apparatus in the meteorograph in the air are both revolving at the same rate of four times a minute, and since their helixes correspond, the movements of the styli in the meteorograph are recorded on this paper. These recordings contain complete records of temperature, humidity, and pressure changes. The instrument is carefully checked before use, in a flight chamber simulating conditions of flight up to 70,000 feet.



Interior of the new radiosonde, showing the hygrometer unit at the top

Hundreds of launchings like these can be made from strategic points throughout the country, and the assembling of records helps in giving a highly accurate forecast of weather conditions. The radiosonde is undoubtedly a far superior device for weather forecasting than kites, passenger balloons, or high-flying airplanes.



Recording helix of the radiosonde is under the flat arm in center of photo

While the radiosonde is not new and the first experimental launchings were made at Harvard University as early as 1935, its latest form as illustrated is vastly improved. Its use for military purposes is obvious. Its possibilities in civil aviation and in other types of weather forecasting are equally valuable and all the advances made in weather forecasting in war-time will sooner or later serve in peace-time.—*A.K.*

DIE-LESS DUPLICATING

Permits Economical Forming Of Small Metal Parts

THE PREPARATION of dies for forming small metal parts has always been an expensive and time-consuming task for manufacturers. This is all the more true when dies are used for short production runs or for making parts for experimental purposes. The war, with its acute shortages of skilled workers, especially die makers, and intensely accelerated production schedules, has made more acute than ever before this

problem of dies used for duplicating small parts.

A solution to this problem has been found by many manufacturers whose products require small metal parts. They dispense with the need for dies by using a number of hand-operated duplicating tools which are capable of quickly and accurately forming metal into intricate shapes and outlines.

This system of die-less duplicating, named Di-Acro, employs shears, brakes, and benders as its basic units. Women or ordinary unskilled male labor can easily be trained to operate them with a high degree of proficiency. These tools are adaptable to production-line work where they can be used to obtain a continuous daily output in large volume. They are also extremely useful in test rooms and engineering departments for building experimental models and testing materials for stress and fracture.

The Di-Acro shear is a precision tool for a wide range of work too light for the floor type foot-operated instrument and too heavy for the hand-operated scissor type shear.

The bender is a precision bending unit. In addition to forming a wide variety of metal pieces, eliminating the need for special blanking or forming dies, it can be used to create shapes and outlines impossible to obtain on regular production dies.

These tools, used in conjunction with the brake in a continuous integrated production process, permit the speedier and more economical production of small metal parts. Now used widely in war production, it is expected that they will find a growing place in the manufacture of civilian goods when the nation returns to a peace-time economy.

ROCKET FLIGHTS

Seen by Expert on The Post-War Horizon

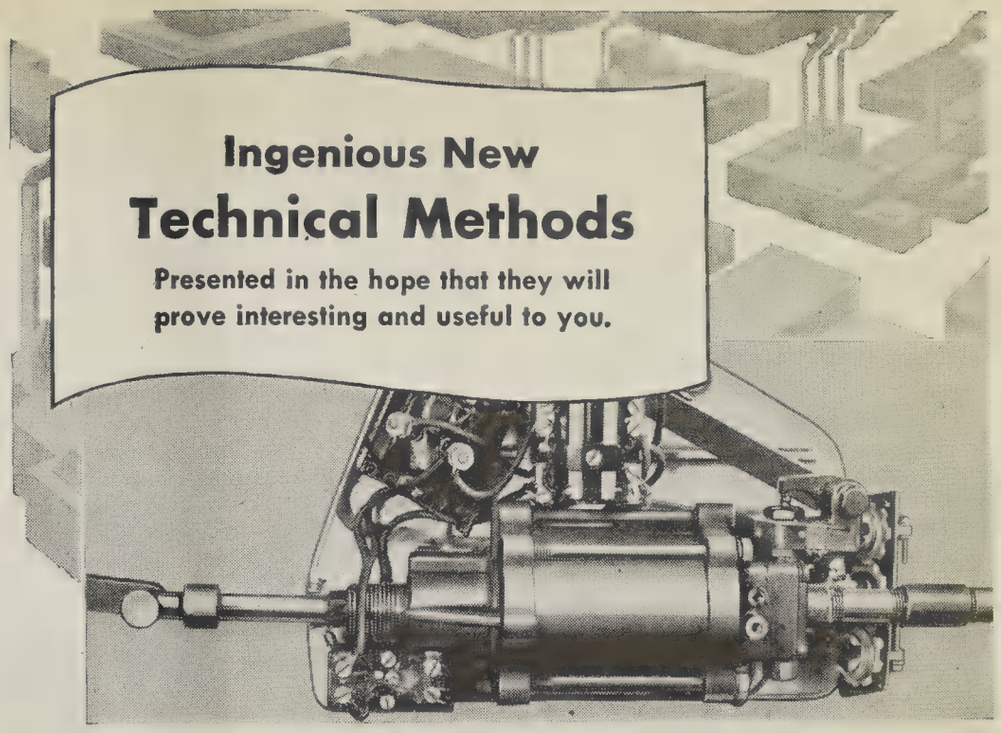
"TRANSATLANTIC rockets are unlikely in this war, but rocket planes making flights from London to Paris will materialize in the not too distant future," according to Alfred Africano, former President of the American Rocket Society, and now engaged in confidential war research as Assistant to the Director of Research, Allegany Ballistics Laboratory, in an address delivered before a meeting of the Metropolitan Section of The American Society of Mechanical Engineers. Explaning why transatlantic rockets were unlikely now, Mr. Africano said the speed required to propel them would necessitate the use of 26 pounds of fuel for every pound of final weight in the rocket, "obviously impractical to build."

"To get the 3000 mile effective range," he said, "and assuming the 4000 mile vacuum range, the required velocity is shown to be almost five miles per second, or the speed that a body needs to keep flying in a circular path around the earth as a satellite at the 500-mile level."

As for the three-step rocket in which fuel tanks are thrown off as fuel supply is exhausted, proposed in 1911 by Dr. Andre Bing of Belgium, this also is impractical, Mr. Africano believes. "The weight ratio increases as a power of the number of steps," he said, "so that the three-to-one ratio would require about 2500 tons initial weight to send just one ton over the Atlantic. Even a war could not justify a 5,000,000-pound projectile at a cost of anywhere from ten to a hundred million dollars just to deliver one ton of TNT in a enemy country. It is also impractical, because even if the energy requirement can be met, the initial damage to the surrounding countryside at the launching stage from the burning of 100,000 pounds of fuel a second for only a five times gravity acceleration might be a hundred times greater than that inflicted by the one ton of explosive delivered in the enemy country."

In discussing the rocket plane, Mr. Africano said: "The maximum range equation I have derived for the rocket plane shows the range to be proportional to the square of the jet gas velocity, as expected, as this is a measure of the available horsepower of the jet. The range is also linearly proportional with the velocity ratio. Thus, for current practical value of the constants, the range might be only 157 miles at a low speed such as 670 miles an hour, 314 miles at double that speed, and so on, up to a maximum of 1400 miles when the rocket plane speed equals the jet gas speed of 5400 miles per hour. The crusing level for this high speed would be at 30 miles altitude."

Summing up the practical possibilities of the rocket plane, Mr. Africano concluded: "While military applications of jet propulsion engines are now possible, as everyone knows, the subject is still in its infancy as far as commer-



Ingenious New Technical Methods

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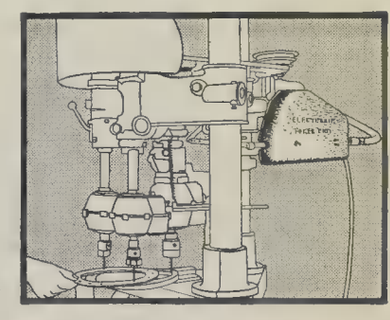
New Electroaire Power Unit Converts Standard Drill Press to Automatic

This exact control over feed and retraction speeds permits ready conversion of a standard drill press with tapping head into an automatic tapping machine, capable of producing Class III threads, even with comparatively unskilled operators. By adjusting speed to conform to the lead pitch of the threads being tapped, the tap will cut without forcing threads, and on the reverse the tap will actually "float" out of the part with no strain against the thread angle.

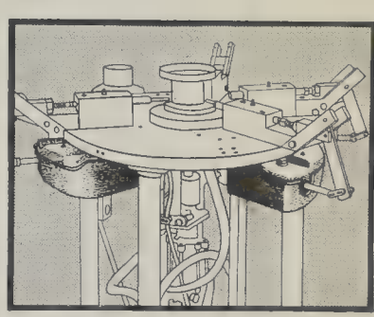
Air-powered jigs and fixtures can be opened, closed, and indexed by the Electroaire Power Feed. The unit can be set for a pre-determined number of cycles so that multiple holes can be drilled in the same piece without ejection, by means of an indexing fixture controlled and synchronized by the Electroaire Unit. One operator can run as many as two or three drill presses, turning out top-quality work with few rejects and with a minimum of tool breakage, thus effecting a great savings in time.

Present stockpiles of finest quality materials used in the manufacture of Wrigley's Spearmint chewing gum are now exhausted—necessitating discontinuance of production. When a supply of proven materials—known to be up to the finest standards of quality—is again available, Wrigley's will resume production—And Wrigley's Spearmint will be back to again help you on your job. In the meantime they are manufacturing a war brand. Wholesome but not excellent enough for the Wrigley brand name.

You can get complete information from Electroline Manufacturing Company, 1975 East 61st Street, Cleveland 3, Ohio



Set up to punch 3 holes simultaneously



Shows holes being drilled automatically

Z-55

cial and peace-time applications are concerned. With adequate support of research and development after the war it is my sincere conviction that the rocket flights to London and Paris we have so long just talked about will finally materialize, and not in the too distant future."

MICROWAVES

Useful for Television
And Other Applications

NATION-WIDE television hook-ups through microwave radio stations 20 to 100 miles apart all over the country were predicted as an immediate possibility as soon as the war is over by Dr. George B. Hoadley, in charge of the instructional microwave laboratory at the Polytechnic Institute of Brooklyn, at a recent meeting of the New York Electrical Society.

While the principles on which national television networks could be achieved have long been recognized by scientists, Dr. Hoadley explained, it took the war to bring about the developments which will hold down the microwaves to the defined and limited beam necessary to operate station links. These links will be placed across the country at 20- to 100-mile intervals and in parallel bands 150 to 200 miles apart, much as the several transcontinental railroads now span the country, making it possible for any event of national interest to be televised into homes throughout the country.

The advantage of microwave links is the fact that communication can be achieved with relatively less transmitter power than would be required for broadcast service; however, microwave boosters still are necessary to link television stations because the range of the short waves they utilize is bounded by the optical horizon.

Release by the military of information and the imagination of American industrial designers will be the two determining factors in the uses to which microwaves will be put in the post-war era, Dr. Hoadley pointed out. Possible applications, he said, may be to increase the availability of radio-telephone communication, now threatened by interference between existing stations. It will be necessary to go to higher and higher frequencies and to evolve new schemes to get around this interference. Another use will be for spanning water gaps by telephone companies to eliminate costly and delicate sunken cables. In fact, Dr. Hoadley added, a microwave relay station can be set up at any point where it will eliminate costly construction and maintenance in carrying through telephone poles and wires.

FOOT-REST SEAT

Foreshadows Greater Comfort
In Railroad Coaches

SOME of the passengers on one of the Seaboard Airline Railroad trains these days are experiencing a new comfort in coach seating accommodations. Four experimental seats with foot and leg rests have been installed for tests and travelers' reactions.

The new seat, designed by the Edward G. Budd Manufacturing Company, is patterned along the lines of the steamer chair, but is actually even more utilitarian. The central arm rest has been doubled in width as contrasted to the standard dividing arm rest, which is usually half the width of the outside arm despite the fact that two passengers have to use it.

The foot rest, in one position, is similar to a hassock. When swung on its pivot against the seat occupied by the passenger, it supports the feet and legs and enables the traveler to enjoy complete relaxation. The seat and foot rest occupy 52½ inches of space. They also enable a traveler to sleep on his side or to curl up in the seat and still have support for the knees and legs.

Each leg rest contains a pocket into which can be placed for safety and convenience a woman's large pocketbook, shoes, or small packages.



More comfort in the railway coach

PREFORMED PLASTICS

Has Tensile Strength
Equal to Steel's

SUCCESSFUL development of a "missing link" in the family of plastics—a tough high-strength material easily formed into complex shapes—has been accomplished by Westinghouse, according to Dr. A. Allan Bates, manager of the Chemical and Metallurgical Department.



An airplane tail fillet made of new light but strong preformed plastics

"Heretofore, plastics have been roughly divided into two classes," Dr. Bates says: "those that could be molded into shapes easily, but had little strength, and those with great strength but little moldability. This new plastics has both strength and formability to a degree never before achieved in a single plastics material."

Called "preformed plastics" because it is shaped roughly to finished form before it is finally molded by heat and pressure, the new material weighs only half as much as the aluminum alloys used in airplane construction, Dr. Bates states. It is so strong that a one-inch-square bar can stand a pull of 16,000 pounds, equivalent to the tensile strength of structural steel.

"After the war," the Westinghouse scientist says, "this plastics will be available for use in hundreds of new products now made of wood or metal—radio and refrigerator cabinets, automobile doors, dashboards and other body parts, luggage, cameras, furniture, typewriter frames, filing cabinets, and many other articles."

Millions of tiny wood fibers, the same kind of cellulose fibers as in ordinary wrapping paper, give the new material its strength, he explains. Under heat and pressure these fibers are tightly locked together with a varnish-like resin to give the finished material its steel-like strength.

Dr. Bates is shown in the accom-

panying photograph with one of the first experimental pieces made by the preformed process—a gracefully-curved airplane tail fillet which resembles a giant man's spat. He says that bullet-shaped covers for airplane propeller hubs have also been made experimentally.

BOX CAR

Has Complete Aluminum Exterior

THE FIRST American railway experimental box-car having a complete aluminum exterior has been designed by Great Northern Railway and Aluminum Company of America engineers. It is equipped so that it can be used for high-speed express service on passenger trains.

Another "first" for the new car is use of a reflective material for monograms and lettering on the aluminum exterior. By using this, words, numbers, and monograms on the sides appear as though internally illuminated and are readable when lights shine on them at night.

The reflective material is "Scotchlite," made by the Minnesota Mining and Manufacturing Company. It consists of millions of small glass spheres coated in a synthetic resin for protection against weather and water. The material, in sheet form, is applied to the side of the car by means of a water-proof synthetic resin adhesive. The tiny glass spheres return the light toward the source of the beams shining on them.

Parts of the new car which use high-strength aluminum alloy are outside sheathing, roof, corrugated ends, doors, floor protective doorway plates, "W" corner posts, running boards, brake step, and other parts. Roof, ends, side sheets, and doors are assembled with aluminum alloy rivets.

The car weighs 43,500 pounds. Saving in weight due to use of the aluminum is 4057 pounds. Aluminum in the car weighs 3722 pounds.

TWISTED DRILLS

Are Demonstrating Many Advantages Over Conventional Types

MANY tons of critical, high-speed steel have been saved during the war emergency by the widespread use of twisted drills in thousands of American factories and machine shops.

A workable method for making twisted drills was developed at the Rouge plant of the Ford Motor Company after salvage experts took steps to reduce the 50 percent waste of expensive, high-speed steel bar stock that accompanies the manufacture of conventional drills.

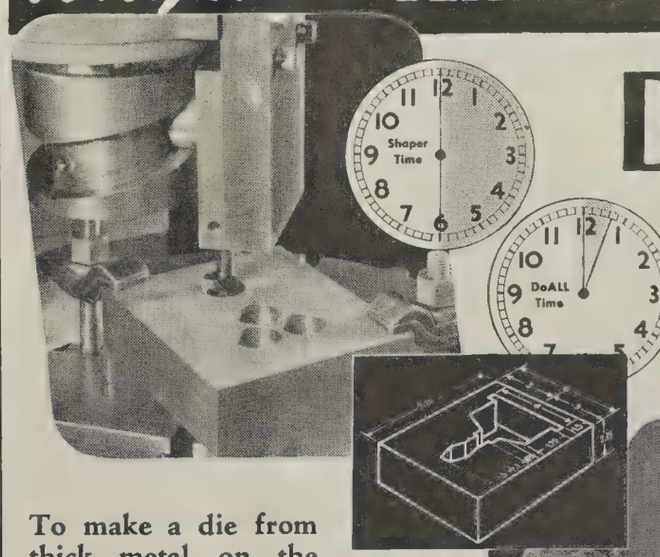
The first twisted drills were made at the Rouge plant some years ago. Advantages of the shankless twisted drills are many, with ease of manufacture and low cost among the most important. Conventional drills are machined from solid bar stock, an operation that consumes time besides producing waste, while twisted drills are made from roll-forged stock of predetermined dimensions and then hot-twisted to the desired spiral. The spiral is produced by roll-forging and twisting, instead of cutting on a milling machine as in the regular drill.

In addition, twisted drills are stronger than the conventional type. There are three reasons for this: the web, or center section of the drill, is of uniform thickness; the twisted drill has better physical properties, since the grain lines in the metal are not cut at spaced intervals, but curve with the spirals like the twisted fibers in a rope; the neck of the shankless drill is toughened by heat-treatment so that it will "give" slightly, thereby cushioning the shock of sudden torsional strains.

On numerous jobs the twisted drill can produce more holes because of its superior strength; in addition, it is less easily broken and has a higher scrap recovery value. More important, when a twisted drill wears to its shortest usable length, it can be butt welded to another short drill and, after the weld is ground and polished, restored to use. Salvage experts frequently weld three or more short drills into a single drill. This salvaging operation is peculiar to these drills. Conventional drills with milled flutes cannot be butt welded properly due to their tapered web.

Twisted drill manufacturing technique is relatively simple. The stock used is purchased in the form of round rods. These are heated to a high temperature, then placed in a form rolling machine. This produces a straight section, resembling the shape of a finished

Why use a VERTICAL Shaper?

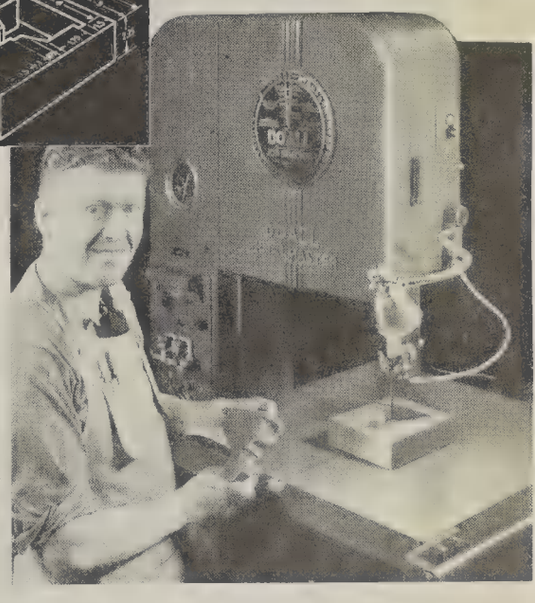


DoALL DOES THIS JOB IN 1/12 THE TIME

To make a die from thick metal on the Shaper calls for large starting holes. Then, cutting tool moves up and down, removing one chip on each downward stroke.

It takes the DoALL only 1/12 as long to make the same die, and the center is removed in one usable piece.

DoALL Contour Sawing Machines are a "must" in every up-to-date metal working department . . .



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DoALL INDUSTRY'S NEW SET OF TOOLS

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drill without a spiral, sufficiently oversize to permit finishing to size later on.

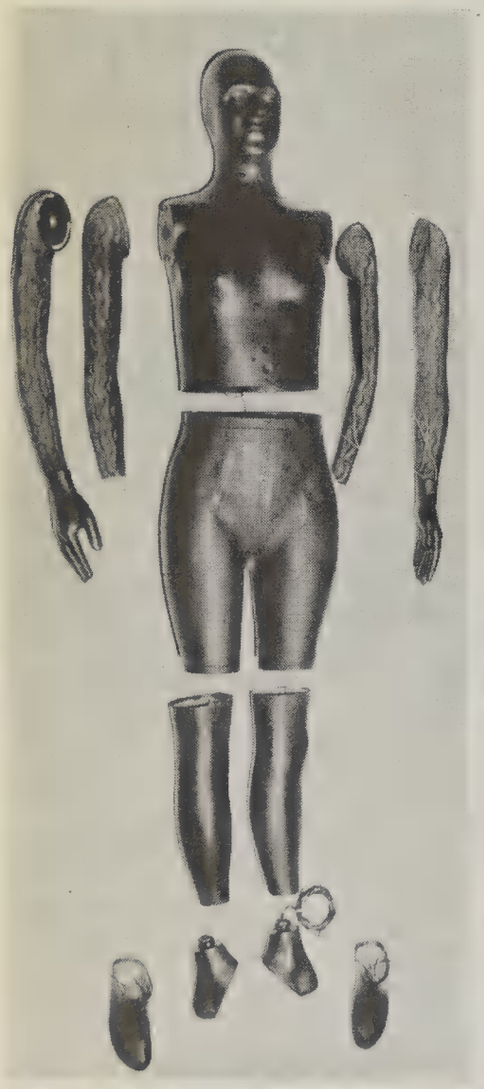
The drill, still red-hot, then goes to the twisting machine. Here the proper spiral or "lead" is produced. Next the long, twisted shaft goes to the cut-off machine for cutting into whatever lengths are desired. The drill is then rough-pointed, heat-treated, tempered, and straightened. It is sandblasted, to remove any remaining scale or roughness, the flutes hand-polished, and it is then placed on a centerless grinder for finishing to a specified diameter.

To complete the operation, the drill then goes to a finish point grinder, where a cutting edge is ground and the point shaped, following which it is inspected for flaws and workmanship and the size etched on the driven end.

COPPER MAN

Replaces Humans in Cold-Room Tests

A LIFE-SIZE "copper man" which reproduces the temperature response of the human circulatory system has been developed as a test machine for electrically warmed flying suits and other similar equipment at the Bridgeport, Connecticut, plant of the General Electric Company. There he will spend a lot of time in the cold room in sub-zero temperatures. In time he will also contribute to the development of the new automatic blanket which General Electric has scheduled for manufacture after the war.



Parts of the "copper man," which reproduces human body temperatures for laboratory research on clothing

Only by "cut and try" methods and by testing which involved people sitting for long hours in a cold room at as low as —60 degrees, Fahrenheit, were the garments developed that have made high-altitude bombing possible. In this work with electrically warmed clothing and blankets for fliers and their implements, cold chamber testing is so vital that it was deemed highly desirable to develop a mechanical device that would simulate the reactions of the human body. Hence the full-size copper man which duplicates almost exactly the human temperature system and provides the perfect scientific answer to the problem of testing electrically warmed flying suits, gloves, shoes, and blankets at low temperatures without inflicting suffering and danger on human beings.

General Electric's copper man is 5 feet 10½ inches tall and has a copper "skin" 1/16 inch thick. A complicated system of electric wires is connected with separate areas of the copper head, torso, hands, and feet.

It is necessary for the human body to generate sufficient heat with which to keep warm. The temperature of the different parts varies considerably. For example, the face and hands, which are normally more exposed, may vary over a wide range of temperature without harm or discomfort, whereas the torso must be kept at a relatively uniform temperature.

The value of the copper man is that he has been so wired and circuited that he practically reproduces the varied heat of different parts and members of the body. His body has been divided into 15 areas, the amount of energy to each area being subject to individual control. His temperature can be made to vary from sub-normal to above normal.

The copper man represents many refinements over similar devices previously used for low-pressure, high-altitude testing. He has two main tricks. First, by maintaining a desired temperature equivalent to the human body, the results can be determined for any kind of garments worn by him under any atmospheric conditions by measuring the energy input together with the surrounding temperature. Thus it is possible to tell what clothing is adequate under given atmospheric conditions. Second, the controls can be set so that the energy is equivalent to that of normal metabolism less exhaled heat. In this case, the copper man represents man at rest and it can be determined how much clothing to put on to keep him warm.

Recognizing the importance of developing better hand and foot protection, the Aero-Medical Laboratory at Wright Field had General Electric make four separate hands and four separate feet and remote control equipment for them. With these it should be possible to determine precisely the proper distribution of heat applied to various parts of the body and the amount of heat necessary with various outer clothing and surrounding temperatures.

NYLON INSULATION

Applied to Wire At High Speed

A NEW nylon compound offers a tough abrasion-resistant substance for sheathing cables or for the manufacture of tubing. Among its advantages as a coating for wire are heat-resistance and its imperviousness to attack by practically all solvents. Ignited by a free flame, the nylon ceases to burn when the flame is removed and is therefore self-extinguishing.

Du Pont laboratories have extruded nylon jackets seven mils in thickness



Adjusting one of the controls on the "copper man"

at rates of over 1000 feet per minute, according to Dr. J. W. Shackleton of the company's plastics department. "A tube of nylon is extruded and laid snugly over the wire, the wall thickness being controlled primarily by the wire speed. Nylon has been proposed as a sealing compound to fill the interstices between individual wires in a multi-strand cable and for use as a barrier layer between materials in the cable which might contaminate each other."

MAGNESIUM WINGS

Point Way Toward Post-War Flight Economies

AIRPLANE wings fabricated entirely of magnesium have been in flight for more than a year on navy training planes, it was revealed recently by J. C. Mathes, of The Dow Chemical Company, speaking before a meeting of the American Society of Mechanical Engineers.

"While the use of magnesium alloys in aircraft has increased during the war to the extent that the average fighting plane now utilizes approximately half a ton of this light metal, the use of all-magnesium structures represents a new departure in aircraft design," Mr. Mathes said. "I am convinced that our success with these wings foreshadows all-magnesium airplanes in the very near future." Since magnesium is one third lighter than aluminum, such planes would be notably lighter than present types, a factor which would do much in making air transportation more economical. "If we can save a few hundred pounds in plane weight we can carry that many more pounds of pay load with no increase in operating costs," Mr. Mathes said. "The saving of a single pound has been estimated as worth $100 a year on a commercial plane."

MATERIALS TESTING

Must Take Into Account All Stresses to be Met

METALS and materials get tired just like human beings. They wear out in much the same way. In a way, they "get diseases," although not as humans do. For some years industry has been trying to find out how much certain materials can stand by using complicated testing machines.

Up to the present most materials testing has been static testing—that is, a bar of steel would be tested as it was, regardless of what modifications might later be made in its shape or size. Industry has found these tests useful, but not good enough. Therefore, dynamic testing came into wide use.

Dynamic testing is simply testing metals or other materials in actual use. For instance, to test bridge strains, models can be made which can be subjected to vibration up to the point of actual collapse. This work will show what happens under actual stress. Or —and this is something automobile manufacturers constantly seek—vibratory tests can be made on an actual automobile to test parts until they fail, to show whether certain parts will give satisfactory life expectancy.

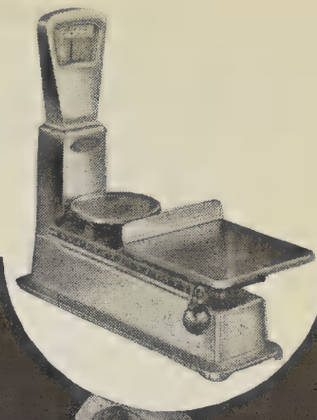
In an automobile, as scientists point out, it is not necessary that a rod or a gear last forever. The car itself will not. But it is important to be sure that any given part will last as long as the car itself—or close to it—allowing for normal wear and tear and sometimes excessive stresses or impacts.

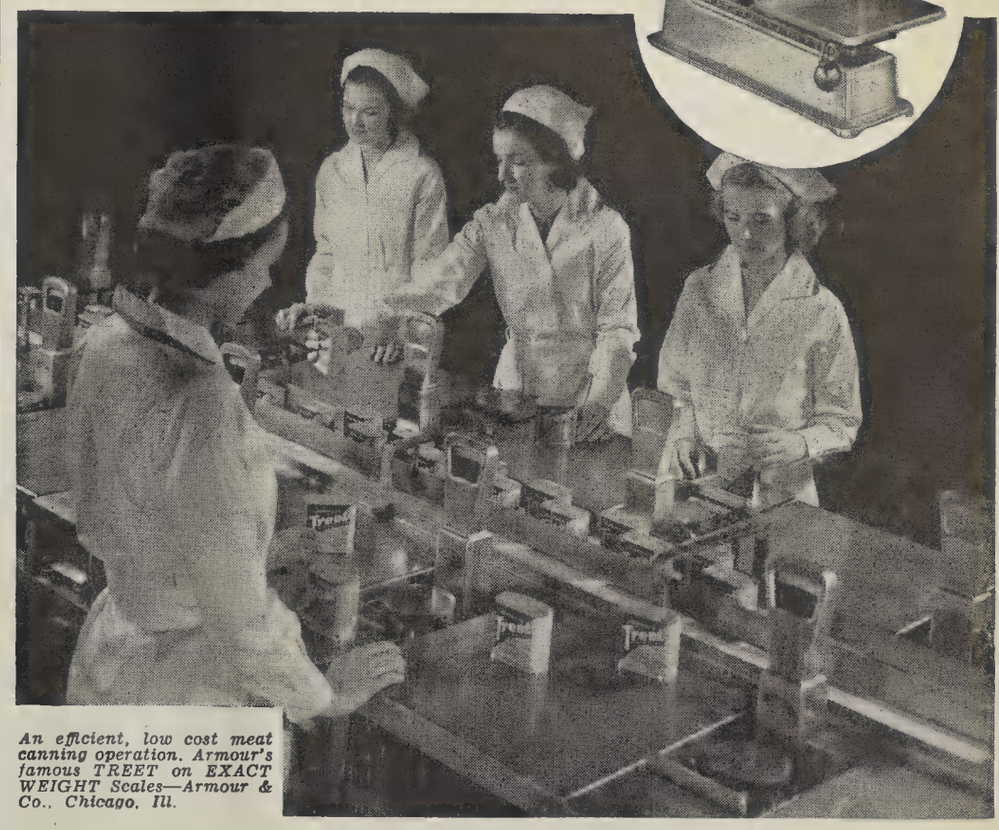
While static tests can test materials separately, the real conclusions can be found only by dynamic testing. These apply not alone to cars and bridges, but to railroads, locomotives, busses, and almost anything used in commerce or in the home—even to sweepers, electric irons, gas stoves, or toasters.

Higher speeds in present-day machinery and transportation have amplified the importance of dynamic forces as a factor in design. Studies made in England by Aitchison showed that 95 percent of the failures in automobile parts were caused by dynamic forces. Hardly any machine part failures investigated by Ross of Sweden could be attributed to static forces alone: 80 percent were caused by repeated stress, and the remaining 20 percent involved impact. A complete knowledge of the behavior of materials as well as structural shapes and assemblies under dynamic forces is thus an acknowledged necessity in modern engineering.

Machinery for making such tests of materials ranges from strain gages, no larger than a postage stamp, to four

Searching for Hidden Ounces in the Food Packing Industry . . .





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Net Weight — 12 ounces. You have seen it many times. Putting food in cans or packages in accurate weights requires skillful plant management, the right equipment, and watchful operators. A quarter ounce overweight in one can is unimportant but a hundred thousand quarter ounces overweight is ruinous. In volume production you package your profits with the goods. EXACT WEIGHT Scales catch these overweights containers . . . ferret out those ounces one by one. Not only are profits protected but packaging is easier and faster. Engineers with such problems are invited to write us for details for solving these problems.

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Exact Weight Scales

million pound monsters. Intimately connected with the design and construction of such a wide variety of equipment is the Baldwin Locomotive Works, reported to be the manufacturers of more testing machinery than any other company in the United States.

STAINLESS STEEL SHOT

Used to Clean Castings of Similar Metal

WHERE cleaning and finishing of ferrous metal castings is performed by means of blasting with steel balls or shot, the repeated impacts of the steel pellets against the castings result in a fine deposit of steel dust being worn away from the pellets and deposited on the casting surface.

This, of course, makes no difference in carbon or low alloy steel and iron castings, but obviously when a surface layer of ordinary steel is deposited on stainless steel, it renders the surface subject to corrosive attack, thus destroying the primary property of the stainless alloy—its corrosion resistance.

The Cooper Alloy Foundry Company, producers of corrosion- and heat-resistant alloy castings, when confronted with this trouble, promptly developed a remedy by using shot, punchings, or filings of stainless chromium-nickel steel for blasting and tumbling castings of similar compositions.

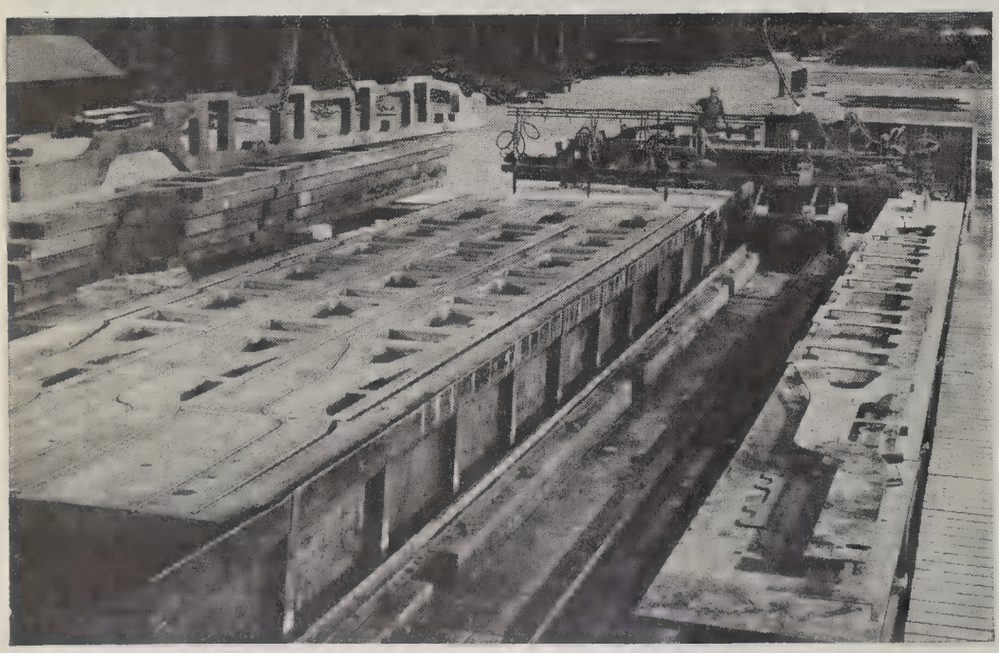
These stainless pellets perform their primary duty as efficiently as ordinary steel; yet the deposit which wears off and deposits on the casting is homogeneous with the casting material itself, and hence equally resistant to corrosion. —*Nickel Steel Topics.*

MULTIPLE FLAME-CUTTING

Takes on New Job in Steel Plant

THAT MULTIPLE flame-cutting is making notable strides into new fields is evidenced by the simultaneous production of three heavy frames of intricate design from a single 40-foot hot rolled Lukens steel plate. The key to the success of the job is in the awareness and intelligent appraisal of factors which affect adversely the accuracy of such flame-cutting and in the application of counter-measures to eliminate such factors.

The feat is being performed daily at By-Products Steel Corporation's plant, where three sizes of these frames are cut from five-inch thick carbon steel plate which has a tensile strength of 75,000 pounds per square inch. Hundreds of such frames are being produced for railway locomotives, most of which will be used as lands are freed in Europe, to restore transportation facilities destroyed by the Nazis or in bombing raids.



Flame cutters in action, with template at the right

CUT-OUTS

Are Readily Applied to Any Surface in the Home

READY-PASTED cut-outs, a new and colorful type of decoration for plain and painted surfaces, are the latest industrial offerings to amateur home decorators. These cut-outs are velvety-soft and blend richly against the surfaces on which they are used, giving a hand-colored, craftsmanlike effect, rather than the hard, enameled look which some other types of decorations give. The blended colors used are harmonious, yet sharp and brilliant. This color harmony is the product of skilful designing and painstaking printing, and result in colors that will blend with almost any interior color scheme.

Fadeproof and washable, these cut-outs need only be dipped in water and then applied to the surface to be decorated. Each one comes on a sheet scored all around, ready to be "popped out" of the background. The pieces are small and easy to handle, and no special equipment is needed—just a basin of water and a soft, clean cloth. You first press the design out of its perforated paper background, then pin it in place in order to judge the effect. Remove the pins and dip the piece in water to moisten the adhesive on the back, and press it against the surface you are decorating, patting it with a cloth. It will not dry for a few minutes, and you can adjust it while it is still wet by sliding it to adjust the position. Your own imagination can be your guide as to placement, although suggested uses as well as detailed instructions are included with each cut-out.



Only a few of the many possible applications of ready-pasted cut-outs

If you should want to remove one of the cut-outs and change the pattern in accordance with a change in your decorating scheme, the cut-out can be removed by soaking thoroughly and peeling it off. Or if you are using a cut-out on a surface which will receive much wear, a quick coating with shellac or clear lacquer will assure special durability and washability.

ARTIFICIAL EYES

Have Improved Qualities When Made of Plastics

A NEW all-plastics artificial eye which rivals a human eye in color and appearance, can be dropped without breaking, won't corrode like glass, and can be re-shaped, if necessary, to provide an exact fit, has been announced by the American Optical Company.

First of its kind to be made commercially, the new synthetic eye is molded from acrylic resin, one of the newer plastics, and production has already been inaugurated. "Prior to the war," the company says, "millions of glass eyes had to be imported from Germany to fill American needs. However, development of the new plastics eye ends the reliance of the United States on foreign sources for artificial eyes."

The new plastics eye, it is claimed, is unique for two reasons. First, it is made entirely of non-irritating plastic materials and, second, its iris is reproduced by a photographic print. Both of these improvements are new in respect to commercially-made eyes and give the eye its radically new properties.

The new plastics eye is said to be more lifelike than a glass eye. For example, the photographic reproduction of the iris is realistic, the black dot of the pupil being located naturally, deep in the eye, instead of close to the surface as in glass eyes.

If dropped, fragile glass eyes may

shatter or chip, and if subjected to sudden temperature changes they may explode in eye sockets. Their average life is from six months to two years while the new eye, because of its plastics composition, is practically unbreakable and will last many years.

Once a glass eye has been made, it cannot be altered. The new plastics eye, however, can be re-shaped by grinding to fit the eye socket comfortably, and it does not have to be removed at night, thus helping to maintain the shape of the eye socket.

Non-irritating to the socket's tissues, the plastics material of the eye resists color fading, corrosive action of eye socket secretions, and changes in temperature. It also reflects less light than a glass eye, and is therefore less glassy in appearance.



Glass eyes cannot be altered after they are made; new plastic eyes can be ground to fit if necessary

The plastics eye is made in three parts. First, the sclera, or white portion of the eye, is molded from a translucent plastics. Then a round recess is cut into it for the iris. Next, the iris button, which contains a photographic reproduction of a real iris, properly colored, is made and inserted into the scleral recess.

In the final operation the sclera and iris button are put into a mold and an overlay of transparent plastics is added. Under the process the three pieces fuse and the finished product is a one-piece all-plastics eye.

WATER-PROOF MAP PAPER

Retains Writing Qualities After Soaking and Washing

PAPER that does not disintegrate when wet is one of the products developed under the stimulus of war needs that will become an accepted convenience of everyday life in the future. At present it has many military uses, one of the latest being for maps.

Developed by the Army Map Service, co-operating with paper manufacturers and the National Bureau of Standards, for use under rigorous combat conditions, the new map paper has greater strength than paper used formerly for this purpose. It retains its durability after being soaked with water and oil and after being trampled in the mud, and later washed with soap and water.

Even when soaking wet, the paper has satisfactory writing and erasing qualities. In addition, it has excellent printing qualities and meets all the requirements of map paper.

The current requirement of more than 10,000,000 pounds a month is being turned out by mills all over the country. Pulps from eastern spruce, southern pine, western hemlock, and the jack pine of the Great Lakes are being used with equal success.

FLOATING REFRIGERATOR

Can Supply 53 Tons Of Refrigeration Daily

THE first all-concrete refrigerated cargo carrier, a floating ice-box which is supplying United States troops with fresh food, is now in action somewhere in the South Pacific.

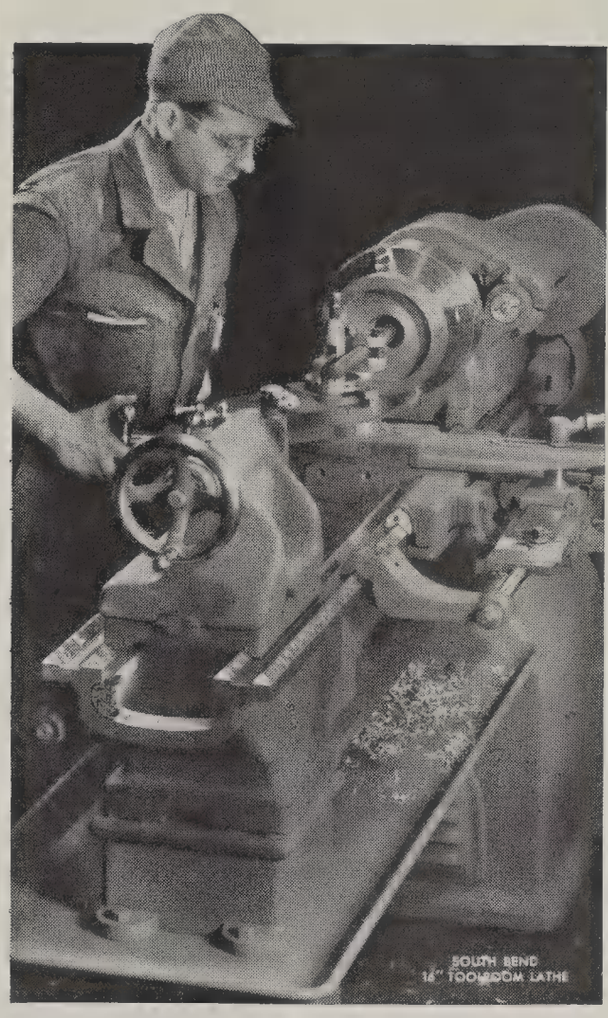
Engineered and equipped by the York Corporation with a unique cold-storage system for fresh meat and produce, the new refrigerated barge is one of three such vessels to be built for the United States Army in the yards of the Concrete Ship Constructors. More than 1000 tons of fresh meat, fruits, ice, and ice cream were carried on her maiden voyage.

At sea, the floating refrigerators will perform the same job for the Army as mobile land commissaries, supplying food for fighting men and ice for emergency treatment of wounded. The ships will be camouflaged and moved into position during attack on main islands. Until the island is secure and permanent refrigeration installed, they will maintain a supply line of provisions between sea and shore. After initial operations are completed, they will be towed to the next scene of attack.

First barge of its type ever built, the new vessel is 265 feet long with a 48-foot beam. The concrete walls of the hull are five inches thick. Reported refrigerated storage capacity amounts to 122,000 feet and includes a plant capable of turning out 500 gallons of ice cream a day. Another plant produces 5 tons of ice daily. All together the ship produces 53 tons of refrigeration every 24 hours.

PRECISION

— AS VITAL IN WAR AS IN PEACE



In every theater of war South Bend Lathes are holding to their pre-war traditions for dependable precision. In the mobile machine shops of our mechanized forces they duplicate factory tolerances on intricate parts needed for emergency repairs on essential equipment. On board many of the Navy's fighting ships, where high precision is an absolute requirement, they are also depended upon for the repair of mechanical equipment. In the repair bases of the Air Forces, they play an equally important part in keeping planes in service.

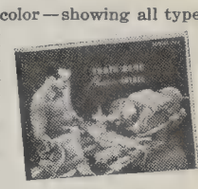
In all classes of war service these lathes are doing fine precision work—not only with the armed forces but also in industry where dependable accuracy is as vital as speed and versatility in meeting war's ever expanding production schedules.

When civilian production is resumed, South Bend precision will again prove as indispensable to peace-time industry as it is now for exacting war work.

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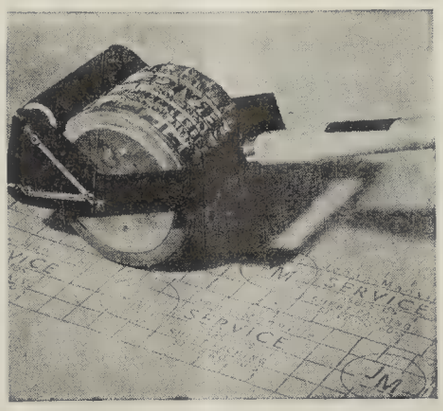
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Representatives in principal cities and Canada.

New Products

MARKERS

DEVICES which can be used to print or mark boxes, crates, cases, and so on, either in a continuous strip or with single impressions, have recently been placed on the market by Adolph Gottoscho, Inc.

These Rolamarker units are available in sizes that will print information to users or manufacturers' identification



Boxes and crates marked quickly

from two inches to ten inches wide. They can be applied to asbestos, cloth, cheese, composition board, plastics, and similar materials.

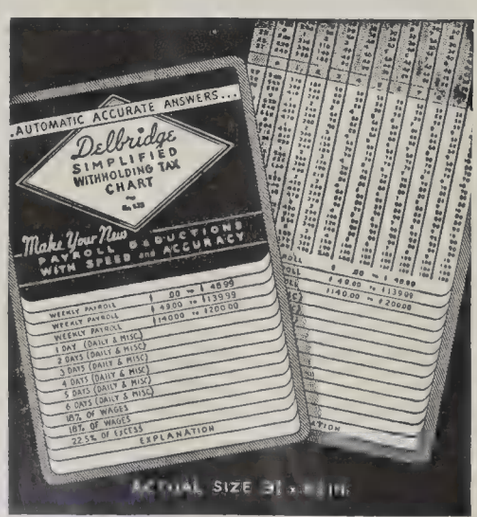
The Rolamarker for single impressions is equipped with a return mechanism so that after the imprint is made and the unit is removed from the surface being marked, the die drum automatically will return to the starting position.

Permanent dies or interchangeable type may be used in these markers. They are all automatically inked by rollers.

TAX CHART

A SIMPLIFIED withholding tax chart designed to help office managers and accountants to make, easily and accurately, payroll deductions under the tax law effective January 1, has been prepared by Delbridge Calculating Systems, Inc.

It is published in four editions covering weekly, bi-weekly, semi-monthly, and monthly payroll periods. In addition, each of the four charts shows daily and miscellaneous deductions for periods from one to six days inclusive. No multiplication or addition is required in using these charts.

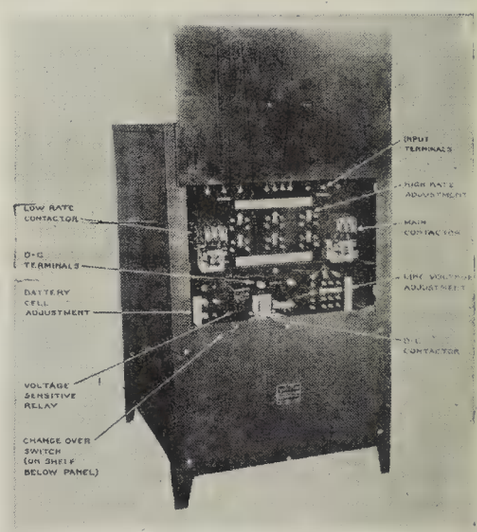


For figuring payroll deductions

BATTERY CHARGER

PRODUCTION of a new large-capacity automatic copper-oxide battery charger, for charging electric truck batteries, is announced by General Electric's appliance and merchandise department.

This combination charger has simplified controls and a D.C. contactor. It is capable of charging 30 nickel-alkaline



Charges electric truck batteries

or 24 lead-acid battery cells. It is designed specifically for applications where both lead-acid and nickel-alkaline batteries are employed.

The charger takes up little room and can be installed anywhere in the operating territory of the trucks that three-phase A.C. power is available.

The internal control panel of the new charger is clearly laid out to enable even an inexperienced operator to make adjustments. Name plates show the method for changing the charging rate, the one-step operation of line voltage adjustment, and the battery-cell adjustment.

The D.C. contactor prevents batteries from discharging back through the charger after the A.C. input has been turned off or fails. The charger automatically shuts off when the charge is completed. When desired it can be shut off manually before the charge is completed.

SAFETY SURFACE

DESIGNED for use in any plant or factory where floors may become wet and dangerously slippery, a new floor brick incorporates an abrasive baked into the

surface. This new floor surface material, known as Empire Emri Tread Floor Brick, is made with a clay base and is fired at high and carefully controlled temperatures. It is impervious to water and is not subject to attack by acids or alkalis, except at a very slow rate.

The surface of the brick is given a non-slip surface by the abrasive, thus not only reducing the danger of falling but giving workmen a foothold which makes it unnecessary to shorten steps or brace themselves, as has to be done on slippery surfaces.

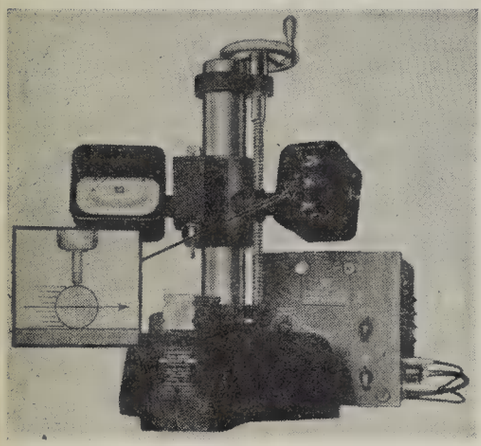
LUBRICANT

A NEW lubricant is being manufactured for all types of internal combustion engines such as steam and gas engines, turbines, air compressors, truck engines, vacuum pumps, and so on. When added to any type of lubricating oil, it produces a "super-lubricant," will not settle out or segregate, and cannot be extracted by any filter.

Bearing the trade name Gibraltar Oil Concentrate, the new product is said to prevent formation of hard carbon on valves and rings when used in air compressors and internal combustion engines. It gives better spreading or wetting action to the lubricant treated and actually penetrates the pores of the metal, according to its manufacturer. Cylinder walls become saturated with oil and, when the walls heat up, the oil exudes from the pores of the metal, giving instant lubrication.

ELECTRONIC GAGE

AN electronic gage is now available which permits inspection of dimensions having very small tolerance limits, at low cost with inexperienced operators. In this Foote-Pierson instrument, gaging is performed electronically and is not accomplished through the use of low-frequency magnetic fields nor does



Unskilled help can read the dial

it depend on the position of make and break electrical contacts. Variations in the position of the mechanical contact point are magnified sensitively, accurately, and conveniently by means of the electronic circuit. The gage is provided with both indicator dial and with limit lights.

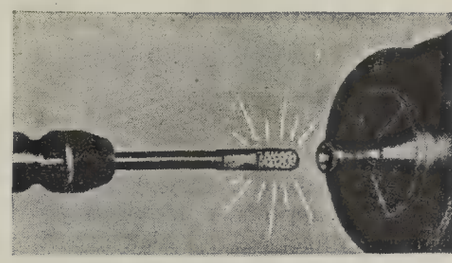
The indicator dial may be used when it is desired to determine how much the dimension varies from the specified tolerance and for selecting workpieces according to their dimensional variations. The indicator dial is also used when setting the gage. The limit lights provide an extremely rapid means of inspection. Any one of the three lights tells instantly the status of the dimension: green means acceptable, red oversize, and yellow undersize. Only one mechanical means for setting to within plus or minus .003 inches is required, since the wide range electrical zero adjustment covers the full scale of plus or minus .003 inches, easily permitting a final zero setting even on the most sensitive scale.

One master only is required and this master need not be to the exact dimensions specified. As long as the gage block or master is within the range of the indicator scale being used, the gage can be set exactly to the specified workpiece dimension.

The gage is set by means of simple radio type knobs; approximate location of the sensitive contact point is obtained manually by means of the lead screw which lowers or raises the gaging head. The gaging head can also be swung 180 degrees in either direction by rotating the column.

DIAMOND BURS

SPECIALLY graded diamond dust, from 80 to 500 grit, impregnated in a special alloy metal bond, makes the Oscap diamond bur a low-cost means of super-



Cuts with diamonds

finishing cutting edges, form tools, drawing or press dies, as well as of internal or external lapping of small holes and gages. It can be used on high-speed steel and high temperature alloys such as stellite, rexalloy, or the hardest grades of cemented carbides.

The diamond bur has a supercharge of diamonds below the regular .050 depth of impregnation, resulting in long cutting life because it will continue to cut after its regular cutting surface is worn away. When the outer cutting surface is worn away, the lower layer of diamonds comes into cutting range.

PLASTICS COATERS

TWO SMALL plastics coaters are now available for melting and maintaining ethyl cellulose and other plastics protective coatings in which parts and tools are dipped. The new models were designed for use by manufacturers of small parts or tools for coating prior to shipment, or for shops that want to protect their own precision cutting tools and gages while in storage prior to use.

Manufactured by the Youngstown Miller Company, each coater has a pump arrangement which provides constant level in the dip tank and continual removal of surface film and

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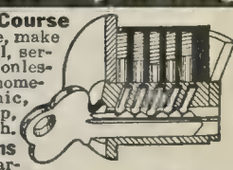


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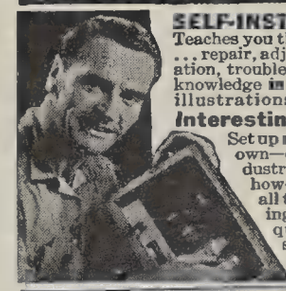
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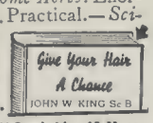
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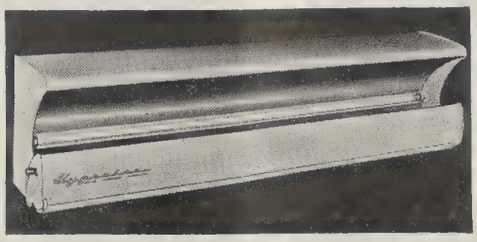
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bubbles caused by dipping. In addition, oil jackets the sides and bottom of each tank. Oil and plastics are thermostatically controlled so that the electric heaters are shut off when either reaches its ceiling temperature.

AIR STERILIZER

THE MOST recent model "Hygeaire" unit for air sterilization employs a General Electric germicidal tube to project intensified ultra-violet rays across living or working areas above



Kills air-borne germs

eye level. A scientifically designed reflector provides both optimum intensity and diffusion of the rays that are lethal to air-borne bacteria. The unit may be recessed into the wall, or suspended from the wall or ceiling.

Because more than 85 percent of the ultra-violet energy output of this new unit is of the germicidal wavelength (2537 Angstroms) it will assist industry in combating absenteeism caused by cross infection in offices and plants. The unit is made by American Sterilizer Company.

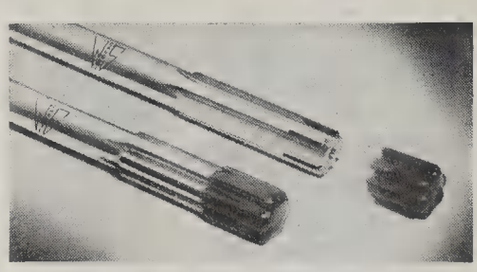
PARTS PROTECTION

NEW methods for the protection of precision machined parts and sensitive surfaces are appearing in industry.

Thread protectors and dust caps for the protection of threaded and machined parts have been put on the market by Precision Paper Tube Company. They are made of spiral-wound fiber, kraft paper, or cellulose acetate,



Protection for delicate surfaces



Sharp edges are kept sharp

under heat-treated compression. They are designed and constructed for durability in protecting fittings and exposed openings and ends from moisture, rust, dirt, or damage in packing or shipping.

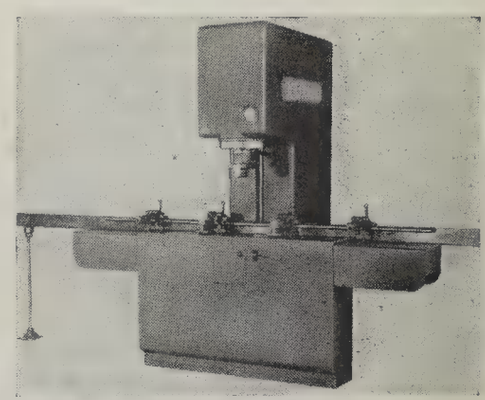
These protectors are shaped to the article to be safeguarded—cylindrical, square, rectangular or tapered, crimped, flared, or perforated—with tolerances as close as ±.003". The name of the part and number, as well as the name of manufacturer can be printed on the protector.

Another example of protection is being practiced by the Wendt-Sonis Company in the safeguarding of carbide tipped tools in transit, stock-room, or tool-room bin by applying a strong plastics coating to each tool immediately after final inspection at the plant.

This hard and durable covering remains in place until inspected by the purchaser and then it can be slipped back over the tool tip to achieve permanent protection in the tool bin. Although the covering is air-and-moisture proof after initial application, it will not leave any gummy residue on the working surfaces when removed from the tip.

STRAIGHTENING PRESSES

A LINE of hydraulically operated and accurately controllable presses has been designed for straightening both finished and rough work. The presses incorporate many of the construction and operating features which have contributed to the successful operation of Colonial



Pressure is registered on gage

Broach Company's other machines and assembly presses.

The machines are of reinforced welded steel construction with built-in motor and with a direct-acting hydraulic cylinder built into the head of the machine. Sensitive control is provided through light-pressure hand control and foot pedals. A pressure gage mounted on the head of the machine in front of the operator indicates the exact pressure being applied to the workpiece.

Straightening fixtures are equipped with either center or roller-type work supports according to whether finished or rough work (such as forgings, upset shafts, and so on) is to be straightened. These supports are mounted on a long guide rail which is particularly useful when long shafts are to be straightened, because they will prevent possible sagging of the work beyond the work anvils.

DRAWING COMPOUND

A DRY drawing and annealing compound applied as a waxy, aqueous emulsion, is announced by the Plasteel Corporation, and has been used with success in the deep drawing of brass and steel. The compound is applied in varying strengths in either drum or spray type mechanical washing ma-

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TECHNIQUE OF PLYWOOD

By CHARLES B. NORRIS

Plywood demand is skyrocketing in the production of wartime housing airplanes, boats, and other defense needs, yet specific information on the material itself is difficult to find. Here, between the covers of a plastic-bound book, has been gathered technical information on all phases of plywood manufacture, specially written for engineers, designers, and users of plywood. (249 pages 5 by 7½ inches, tables and drawings.)—$2.50 postpaid.

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chine at an operating temperature of 175 to 185 degrees, Fahrenheit.

The coating contains sufficient annealing compound to prevent the formation of hard mill scale during anneal, but does produce a thin, porous, protective scale that is easily removed in subsequent pickling, leaving a clean, scale-free piece.

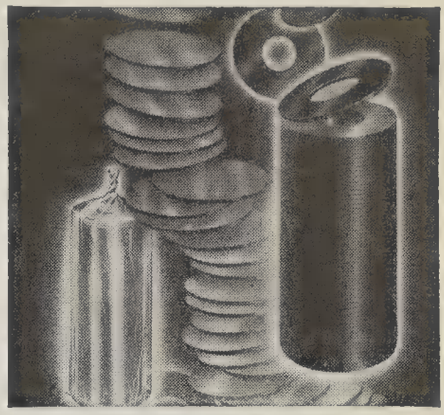
The pieces can be drawn as they come from the washing machine without the use of a coolant or added lubricant. This gives a final product that is smooth and clean.

EXPLOSION-PROOF MOTOR

A NEW explosion-proof electric motor is totally enclosed in a bronze casting with removable screw cover and adapted for conduit mounting. It can be supplied in various shaft speeds, voltages, and frequency. Said to be explosion proof by its manufacturer, the Warren Telechron Company, the new motor was developed primarily for use in connection with automatic controls used in industrial processes where atmospheres contain explosive vapors.

RHEOSTATS

MANY types and sizes of continuously adjustable carbon rheostats formed of carbon disk piles are being manufactured by the Stackpole Carbon Company. Simply by changing the pressure applied to these piles, every possible resistance value within their range is made available without opening the electrical circuits in which they are connected. The pressure to vary the resistance to the most critical adjustment may be applied electrically, mechanically, centrifugally, or hydraulically. Uses range from both generator and line voltage regulator applications to speed control through governed field current on motors. Many other projects incorporating the carbon pile resistor are now in the development stage.



Pressure changes the resistance

METAL DEGREASER

A METAL degreaser and cleaner containing a finger-print and body-acid neutralizer is being manufactured by the Colonial Alloys Company. Even the most carefully cleaned and handled



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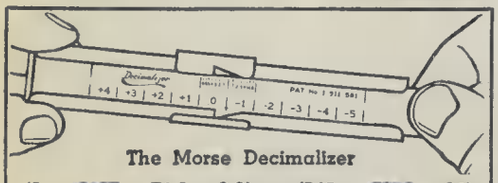
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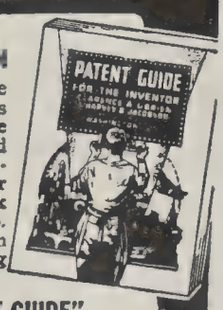
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work going through the various routing and shop operations prior to final finishing, picks up finger-marks, most of which are acidic. It is this acid which, if not quickly neutralized, oxidizes the metal surfaces long before the finishing operation is reached. Too often the finish is blamed, when the trouble really centers on proper cleaning and neutralization of the metal surfaces.

MASKING STICKERS

An efficient method of masking name and instruction plates, now being widely used in war plants, has been developed under the trade name of Kum-Kleen masking stickers. They are available die-cut to the exact specifications of the manufacturer. The name

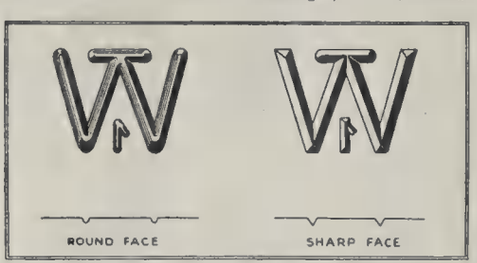


These masking stickers protect name plates during the finishing process

plate is attached to the product on the production line, covered with the masking sticker and the product then painted or finished. These masking stickers, in addition to being die-cut, are applied without moistening, stick to any smooth surface, are not affected by heat or cold and easily peel off without leaving a trace.

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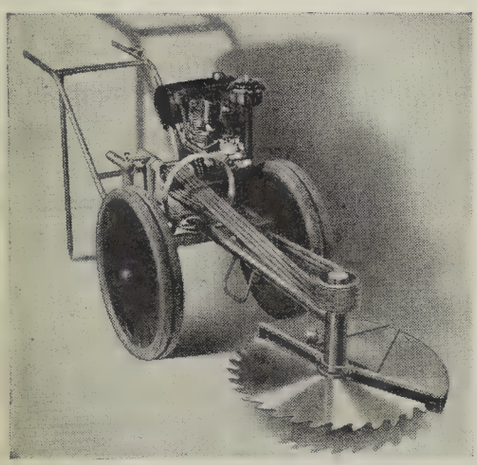
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V-belts drive the blade

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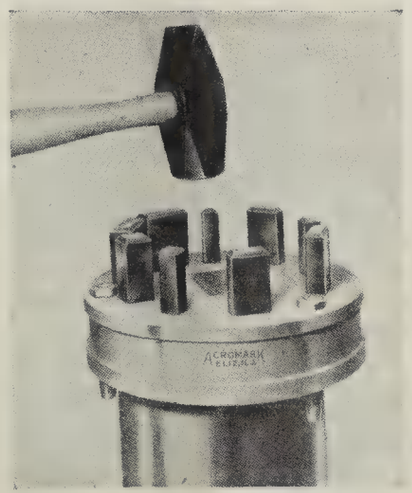
A RECENTLY developed synthetic, called chlorinated isopol, available in metal primer formulations and in powder form, is said to be practically identical to chlorinated rubber in flame resistance, moisture resistance, chemical resistance, solubility, stability, and compatibility with plasticizers.

Among its suggested uses are as a primer for rubber-to-metal adhesion; as an ingredient in adhesives, paints, lacquers, and inks, and as an acid- and an alkali-resistant coating for metal, concrete, and other surfaces. It is also useful for fire-proofing or moisture-proofing fabrics and other materials; for sound and heat insulation qualities; and as a plastics wherever inertness to chemicals and fire-proofness are of importance.

Although the new product is not yet standardized in viscosity range, the Union Bay State Chemical Company has announced that production is sufficient at present to enable sampling and service of reasonably sized orders.

MARKING DIE HOLDER

A NEW style die holder facilitating the marking of all types of ordnance and automotive parts too large to be handled has been announced by Acromark. It is said that the compact self-contained unit holds all marking dies in exact position ready for stamping. The face of each marking die is protected in the holder so that it may be quickly placed in marking position without danger of scratching the work.



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GAS GENERATOR

A NEW model of the generator which produces dry chlorine dioxide gas from chlorine and dry sodium chlorite has been developed by The Mathieson Alkali Works. The chlorite is now contained in a reaction tower within the control unit, in contrast with earlier models



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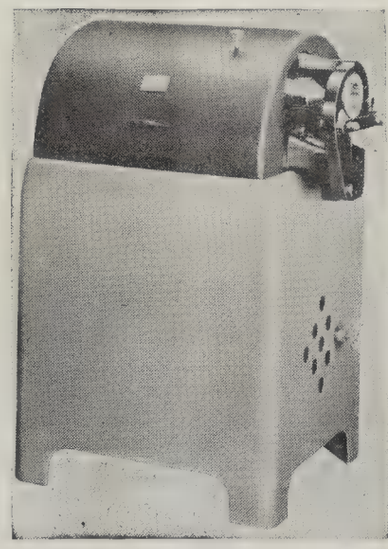
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which required separate chlorite towers. Removable front and sides make all parts of the unit easily accessible for servicing. The new generator measures five feet in height, two feet in width, and 18 inches in depth.

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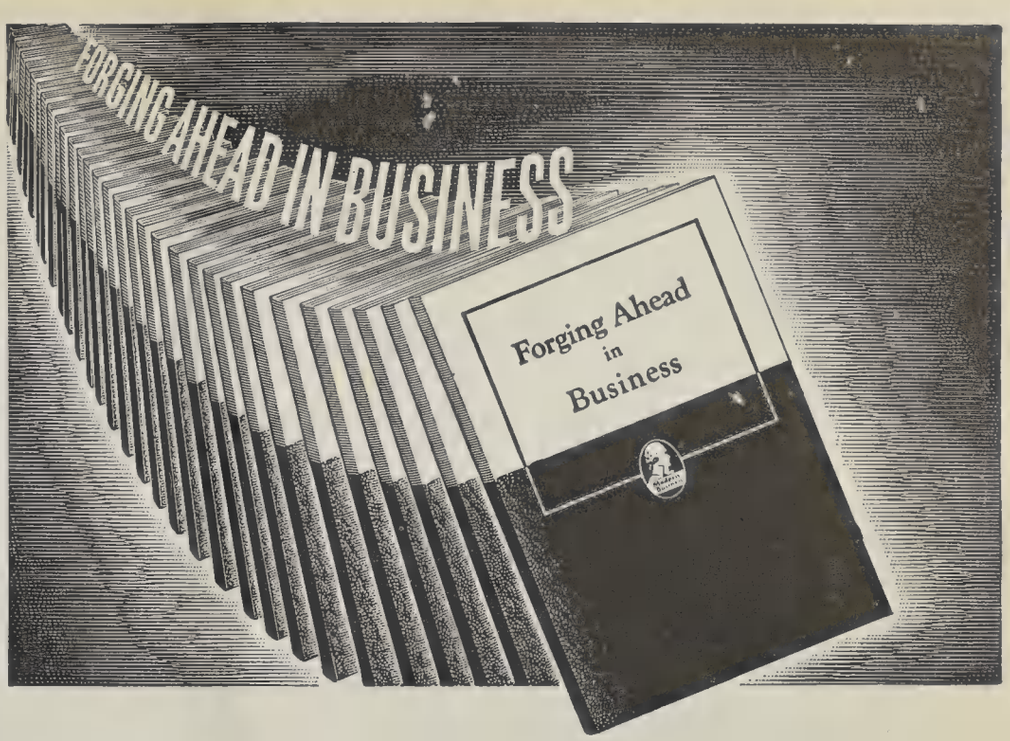
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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN MAKING achromatic objectives for refractors, an approach from another direction than the more familiar one is described below by Patrick A. Driscoll, 39 Bateau Terrace, Rochester 12, N. Y. While this "testplate method" involves a little more work, it requires no optical flat and avoids other headaches.

Asked to tell about himself, Driscoll says: "In 1930 I stumbled across the telescope making hobby when I was a ship model fanatic, and suffered a direct hit in the superstructure. I have had Carbo in my teeth ever since, having been an 'A.T.M.' (amateur telescope maniac) and made a 5" and two 6" achromats, also eyepieces, prisms, and so on. I am now an experimental lens maker employed by the Eastman Kodak Co., Hawkeye Works. Thus you might call me a sort of amateur professional amateur." His article:

SPECIFICATIONS—The data in Figure 1 —the radii, r, each r being numbered with a subscript, and thickness t, similarly numbered—have been very carefully calculated to produce an ideal telescope objective. All tolerances have been worked out to give the greatest permissible leeway, for error in measurements.

Crown component: Bausch and Lomb Optical Co. (Rochester, N. Y.) Light Barium Crown LBC-2, N_d 1.5711, V 57.3, thickness at center 17 mm, diameter

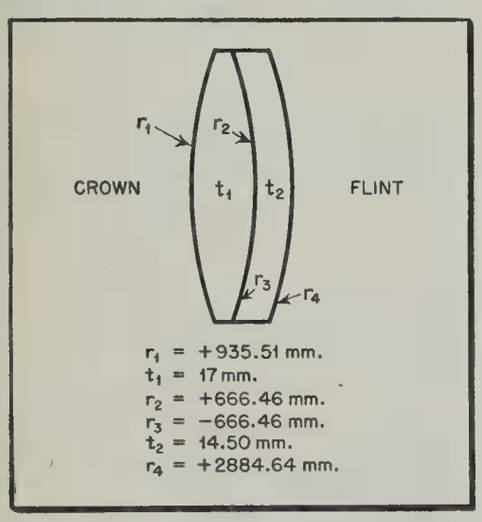


Figure 1: Specifications

4⅞" (thickness of blank 19 mm, diameter 5¼").

Flint component: Bausch and Lomb, Extra Dense Flint EDF-2, N_d 1.6890 V 31.0, diameter 4⅞", thickness at center 14.5 mm (thickness of blank 18.5 mm, diameter 5¼").

Finished diameter, 125 mm; e.f.l., 1480.82 mm (58.30"); focal ratio 11.84.

Hold thickness of each component to plus or minus 1 mm; radii to 1 in the third significant figure (for example, plus 666.46 would be passable at 665.46).

To convert millimeters to inches, divide by 25.4.

METHOD—In place of the method involving regrinding or repolishing the fourth surface to correct variations of curves on the other three, we shall first make concave test plates, or masters, to match the desired curve of each lens surface, controlling them by our familiar old friend the Foucault knife-edge test, and then test our lens surfaces against these test plates by means of Newton's rings and the simple setup described in "A.T.M.," page 244. We shall then be sure that, since the original computations and specifications by which we make the masters are correct; and since we shall make the masters correctly to them; and since we shall make the lens surfaces faithfully to these masters, our achromatic lens itself will be—must be—correct.

Making our test plates will be exactly like making spherical mirrors, but four spheres look like a lot of work. Let's investigate.

Surface 1, the r_1 surface of Figure 1, calls for one test plate.

Surface 2 will be worked against surface 3, tool-and-mirror fashion; surface 3 becomes the test plate for surface 2.

Surface 4 calls for a test plate.

Net extra labor, therefore, two temporary test plate curves—minus the job of making a flat.

For the first of the surfaces—surface 1 (+935.51 mm)—we shall use the crown blank as the tool and work a 5¼" disk of common one-inch plate glass to the corresponding concave radius; roughing, grinding, and fine grinding precisely as in producing a spherical mirror, as described in "A.T.M." To obtain the desired curvature, an arc of radius 935.51 mm is scribed on a thin piece of window glass at least 14" long, using a glass cutter, and this glass is broken apart to make a template ("A.T.M.," pages 310, 344); the best 6" section that shows evenness of break being used. Our tool, when this is done, will be our crown component and will have been completely fine ground to curve on one side.

For the other test plate, the one for surface 3 (—666.46 mm), we use the other side of the crown as the tool and the flint as the "mirror," proceeding as before. The result is the flint fine ground to —666.46 mm and the second surface of the crown similarly fine ground to the corresponding plus curve. This finishes the grinding of the crown; care, of course, having been taken to bring it to the desired thickness—the computations called for 17 mm and we started with 19 mm, a 2-mm leeway for grinding. We also have, as has already been stated, a 1-mm plus or minus tolerance on thickness of either component. This will eliminate elaborate miking devices and automatically chloroform that bugaboo of the amateur optician, the fear of deviating from stated formulas. We would not ruin our reputation in optics nor would we spoil the performance of our objective lens if, on completion, the latter were to come out with a crown curve, for example, of plus 666.00. Any such small percentage of error still will produce a *good* achromat and a pleased maker.

In grinding a lens having a curve on either side it is important that the surfaces be centered with respect to each other; that is, that the optical axes of the respective surfaces be made to coincide longitudinally; otherwise we shall have what is termed a

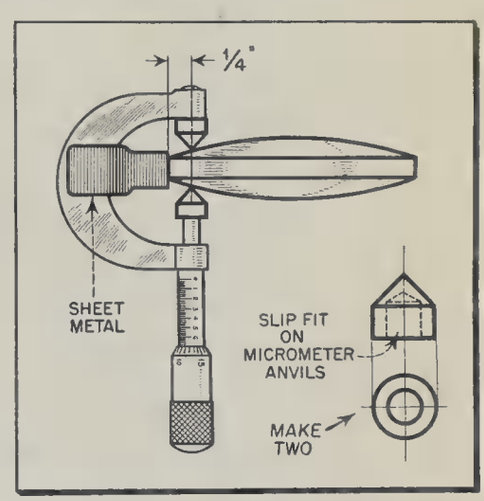


Figure 2: Adapted mike

prismatic lens and this "prism" then could be removed only by centering the lens far below the diameter we want. The 5¼" blanks have enough excess of glass for centering out slight errors in edge thickness but, when grinding the second sides, we should occasionally check the thickness at several points around the circumference. Micrometering is best but measuring with a steel scale will be satisfactory at this stage. The mike shown in Figure 2, with some kind of stop-block attached, will give very accurate readings, but such close readings—an alternative for the most exacting amateur—are unnecessary.

If one side shows thicker than the other, apply more grinding to the thick side. Stop occasionally moving around the lens and make extra strokes on that side.

For the last step in the grinding operations we now take our flint blank, which is already ground to the —666.46 curve (surface 3) and, turning it over and using it as a tool, place the plate glass test plate (which already has the —935.51 curve fine ground on it) flat side down and once again make a concave surface, this time —2884.64. When this concave test plate

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is finished in its fine grinding, the last side of the flint lens is also finished to +2884.64 so far as grinding is concerned. Care is taken again to bring it to tolerated thickness and to check for prism. Our test plate also is finished, so far as grinding is concerned, since it now has concave curves on both sides. This eliminates a second plate glass blank and gives us something to feel really bad about if we drop it.

The flint lens, having a concave surface on one side—exactly the same curve as the convex surface of the crown—automatically becomes the third test plate surface; the only drawback being that, in placing the flint and crown together for testing purposes, care must be taken not to slide them and scratch the flint lens.

In all stages of the fine grinding on all the surfaces of the test plate and components we have made every effort to fit the lenses tightly to the template.

Because emery, which is graded in mesh sizes, is more consistent in grain size than Carbo, I prefer to do grinding with emeries. Suitable emeries are made by Bausch and Lomb and by the American Optical Co. Since the time lost in washing up and changing during use of very elaborately graduated series of emeries, such as eight sizes, tends to annul the time saved by their use, three sizes only—No. 180, No. 500, and No. 1200—will fully suffice and will produce perfect work.

This will be especially true if the micrometer is used for measuring glass removal and for controlling the old bugaboo, pitted edge. Before grinding is started, a permanent mark—nick with a file or a glass cutter—is made on the edge of the blanks. After the lenses have been brought to fit the template with No. 180, they are miked near this mark and the reading is written down. At least 0.008" of glass thickness must then be removed with No. 500 in order to wipe out all pits left by No. 180. At least 0.004" additional must similarly be removed by No. 1200.

During work on all sizes the familiar trick of inverting and working the tool on top should be made available for helping to arrive at gage fit.

In roughing out with No. 180, a long stroke—almost edge to center—may be used.

If the mark is overshot in the 500 stage, the curve may be brought closely to gage through resort to several alterations of inversion and return. No departure thicker than an average sheet of writing paper should be permitted to creep in at the second and third stages.

In all stages of emery it is most important to spread it evenly. A blob of emery in the center will dig its own hole, and a smear on the edge will turn the edge.

The emery should be watery, not thick. In the 1200 stage it should not be allowed to dry out too much. A wet mixture cuts faster and reduces the likelihood of scratching.

After the 500 stage, and again at the 1200 stage, the edges should be beveled slightly with some 500 and a small piece of glass. To eliminate any chipping of the edge the bevel should be retained throughout the 1200 stage and throughout polishing.

POLISHING—Now, after many tedious hours, we are ready to polish. Let the good worker's rule be: "Never polish one side until the other side is ground." Thereby hangs the tale of no scratching.

The test plate must be polished first, in order to give us a master reference to apply to the crown and flint curves.

In polishing we can once more refer to "A.T.M.," page 85, for procedure; except that, having polished innumerable lenses both by machine and by hand, I wish to make a suggestion that will immensely benefit the amateur, both in polishing time saved and in the figure produced. That is, to make our polisher 6/5 the diameter of the lens, when working with lens on top of the polisher, and 5/6 the diameter of the lens when working with the polisher on top.

In polishing lenses of such long radii, it is not necessary to have a curved polisher base. For a base we can use flat plywood disks, heavily shellacked. Let the thickness of the pitch be approximately ⅜" and, when the pitch is shaped to curve, scratch lines into it to form about ½" squares about 1/16" deep. Lines this close and this shallow will flow in more quickly than a more familiar kind but will give more polishing facets. They will also facilitate the rouge flow, and keep better contact with the lens. Do not try to cut them in an absolutely even pattern; merely scratch them freehand, as they flow in.

The —935.51 curve on the plate glass test plate will be our first polishing surface, and here we can take heart in the fact that neither side of the test plate has to be completely polished out. It is necessary only that we have a fairly good polish on it so that under Foucault's test it will give a reasonably bright reflection. Don't worry about pits but, if you feel that a test plate surface should be perfectly polished, then polish it perfect and accept my commendation on your perseverance.

We set up the Foucault test to find our radius of curvature and in so doing we once more digress from the familiar method, substituting for the opaque knife-edge a piece of thin glass (microscope specimen slide?) frosted on one side, and for the pinhole a ¼" hole covered with coarse wire mesh (window screen), arranging these so that knife-edge and pinhole will move always equidistant from the lens. These are shifted to the point where the image of the pinhole is sharpest on the ground glass. With a steel tape, one end held by our partner (friend wife?), this distance is measured from the center of the test plate. My experience has been that any good steel tape will measure accurately within the tolerance to which we are working. One half millimeter is close enough. If over or under the specification, the test plate curve must be brought within the tolerance by polishing.

Driscoll's instructions will be continued next month but the specified glass is temporarily unavailable: war.

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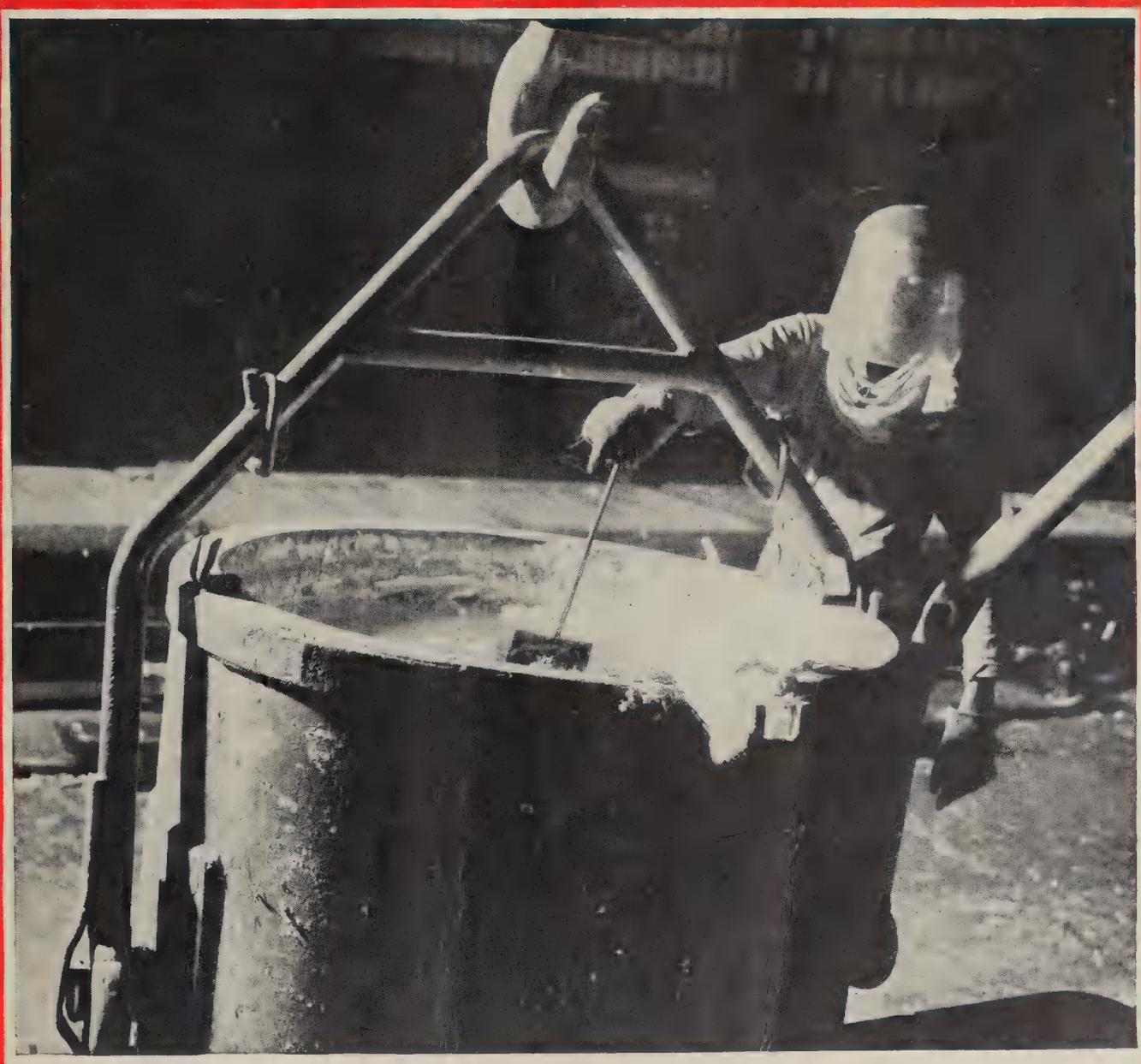
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Scientific American

★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Dross is Skimmed from Molten Aluminum . . . See page 193

The Story of METALS IN INDUSTRY

Anniversary Issue
No. 4



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Our Cover: After the dross has been skimmed from the top of a crucible of molten aluminum, the hot, liquid metal is poured into molds, skimmed again, and then allowed to freeze into pigs. Photograph used by courtesy of Reynolds Metals Company.

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Previews of the Industrial Horizon

By A. P. Peck

A WARNING ON PLASTICS

GREAT as are the uses and possibilities of plastics, it must not be forgotten that there is no one plastics that will fit all requirements. Herein lies a danger to the future of plastics. In the rush to make use of the valuable properties of plastics, there is a possibility that they will be misused, will not be properly selected for the purpose in hand. When the use of plastics is considered for a new product or as a replacement for some other material, due consideration must be given to the requirements. Strength, rigidity, color, temperature resistance, dimensional stability, and so on, must be considered first and then that plastics selected which most nearly meets the specifications. To proceed otherwise can only result in probable failure and the loss of a market for a plastics.

GYPSUM TOMORROW

WHEN the promised post-war building boom becomes a reality, one material that is really going to cash in on new construction and on renovation is gypsum. Where formerly gypsum was known only as a standard plaster for use on interior walls and ceilings, it now has expanded its usefulness to include gypsum lath, fire-proof sheathing, and prefabricated gypsum wall board that can be weather-proofed and will not change dimensions with changes in weather or temperatures.

By no means the darkest part of gypsum's horizon is the fact that, always low in cost, its cost has hardly changed since pre-war days, while lumber and other building materials have skyrocketed in price and have become scarce.

MODELS SHOW THE WAY

INDUSTRIAL engineers charged with layout projects for plants of all kinds are showing increasing interest in the use of models that save time, labor, and materials and at once permit accurate visualization of plans. While these models—three-dimensional plant layouts—are of tremendous help to engineering study, they have the added advantage of showing non-technical persons exactly what the engineer has in mind. Thus the executive staff of an organization can be kept completely informed regarding a proposed plant layout without having to wade through a welter of blueprints and a maze of technicalities.

MULTI-USE GLASS

MOLDING and welding glass by the use of high-frequency electrical waves point the way toward innumerable new uses of this old material, especially in the household. This latest Corning development holds promise of glass stoves, electric toasters made with glass, and a whole family of new glass cooking utensils. Add to these applications the possibility of insulating parts of intricate shape and with close dimensional tolerances and you have a peek at the glass horizon where many articles will be made of glass which heretofore have been only in the dream stage.

Like so many other developments of recent years, this new glass technology was born of war demands. It is being used today to fabricate parts for radar and other communications equipment where physical shock may be great and where previously known glasses and porcelains would not render satisfactory service.

By the new Multiform process, glass can be molded with accuracies to one thousandth of an inch; can be cut to complicated patterns and provided with threads, holes of all sizes and shapes, or metal inserts where required; and can be welded to form strong joints with itself or with metals.

To the conventional methods of producing glass parts—blowing, pressing, and drawing—must now be added a fourth. And this fourth method overcomes many of the limitations of the other three, bringing glass into an industrial prominence such as it has never known before.

CANS CAN DO IT

DUPLICATE machine parts and instruments packed in sealed cans are a distinct possibility post-war. Proof of the value of can containers for such jobs has been furnished by airplane starters, generators, instruments, and the like, that today are being shipped to hot, humid areas in the Pacific, and are arriving in perfect condition. It is reported that this protection given by steel cans is obtained with a 50 percent reduction in container cost.

NEW FIELDS FOR RAYON

RAYON capacity has not increased since the beginning of the war, but the probabilities are that it will burst forth with greater vigor than ever just as soon as conditions permit. Reason behind this is that the industry was almost ready to break into new fields when the war put a stop to expansion. Thus, there is a new rayon filament that looks like a strong competitor for wool in carpets; a high-tenacity rayon that will make better hosiery than present rayons, although not as good as silk or nylon; a short-staple rayon that is spun and used alone or mixed with cotton or wool to give a fabric with a wool-like feel; and the new high-strength rayons, one of which, made by Celanese Corporation, is said to be stronger than nylon but without nylon's elasticity.

ELECTRICITY ON THE FARM

LESS than half of the farms of the United States have electricity available. True, high-tension lines have brought this versatile servant to hundreds of thousands of farms, but the market has only been barely touched. High-tension lines are expensive and cannot be run everywhere.

Here, then, is a place where local generating plants, supplying power co-operatively to a group of farms, can do a real job. At present approximately 800 such co-operatives are generating power that is used by about one million farms, and plans call for at least doubling this capacity in the near future. Many of these co-operatives, using Diesel-powered generators, are giving farmers uninterrupted electric power at lower operating cost than any other method.

FOR FUTURE REFERENCE

ALGIN, product of seaweed, has vast chemical possibilities in such diversified fields as leather finishing, hand lotions, boiler compounds, film bases, and custard puddings. . . Electric trackless trolleys have shown a 1628 percent increase in passengers carried since 1934. . . A new Bendix "air position indicator" that gives continuous readings of latitude and longitude is completely automatic and has vast implications for post-war world-wide air transportation.

Helping the sick get well

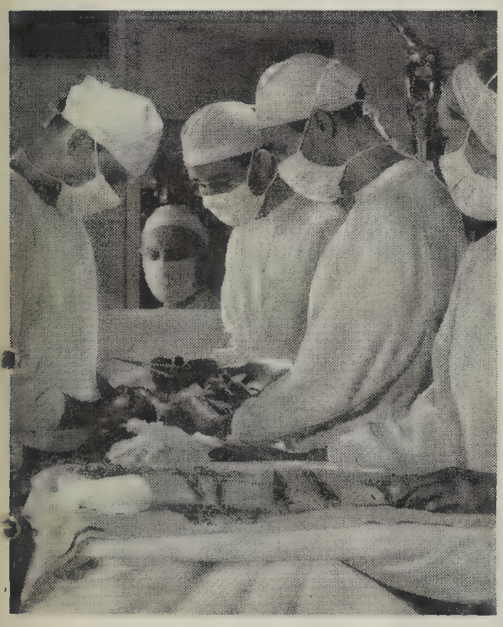
LAMPS that kill germs . . . X rays to guide the surgeon's fingers . . . operating rooms bathed in glareless light . . . air conditioning to screen out street noises and dust.

Helping the sick get well is only one of the contributions of General Electric. From the research and engineering in G.E.'s laboratories come products to make your work easier, your home brighter, creating new comforts, better jobs.

The pictures you see here are typical of things accomplished for you by G-E research and engineering. *General Electric Company, Schenectady, N. Y.*



Mirror of D-Day injury! How X rays speed treatment of war injuries is shown in this picture of Seaman Brazinski's thigh. On D-Day a German mine shattered his boat, blew him 20 feet in air. Rescued by an LST, rushed to England, X rays quickly defined his injury, permitted accurate setting. Portable G-E X-ray machines at St. Albans Naval Hospital, L. I., regularly check his progress. Through the skill of doctors 97 per cent of the wounded in this war are saved. The modern form of X-ray tube was invented by Dr. W. D. Coolidge, G-E scientist. X-ray units built by the G.E. X-Ray Corp. are at battlefronts the world over.



New lamp kills germs . . . Germ-laden air is purified by the new G-E germicidal lamp. It is already at work in hospitals, in battlefront operating rooms. Tried in a school classroom during a measles epidemic, only one-fourth as many children contracted measles, as compared with unprotected classrooms.



Seeing the invisible . . . The electron microscope, more powerful than ordinary microscopes, gives doctors a new tool to fight disease. Here is the germ, *bacillus subtilis*, magnified 8,000 times. G-E engineers are working to make available a *portable* electron microscope for industry.



Helps treat Infantile Paralysis . . . Doctors wanted hot packs to relieve pain and reduce muscular spasms, but such steam packs tended to burn. G-E workers put together a machine for hospital use that produces heated packs that even at 180°F. will not burn the patient's skin.

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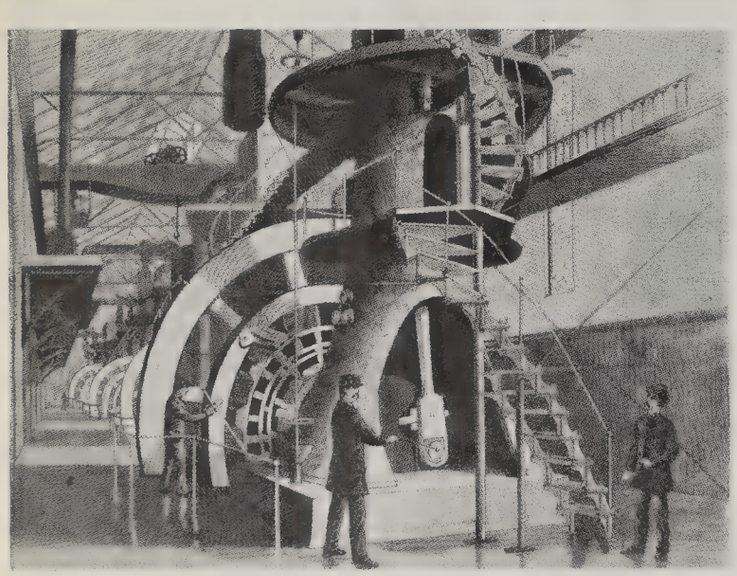
SCIENTIFIC AMERICAN

(Condensed from Issues of April, 1895)

MICRO-ANALYSIS — "At a recent conference, held under the auspices of the French Society for the Encouragement of National Industry, M. Osmond described a method for the microscopical analysis of steel. . . M. Osmond examined four types of steel, possessing a known proportion of carbon, to discover the manner in which these combinations varied. As a result of that investigation, M. Osmond states that the thermic treatment of the steel leaves in the structure of the metal, when cooled, characteristic indications sufficiently precise to form a useful guide in the manufacture of steel, and also to enable consumers to determine the quality of the metal supplied to them."

HELIUM — "Lord Rayleigh, who so recently discovered 'argon,' a new constituent of the atmosphere, has succeeded in finding helium in a Norwegian mineral. This substance was believed to exist only in the sun and in a few stars. . . From its associations and the particular region of the sun where helium is found, this gas is looked upon as being one of the lightest materials composing that body, possibly almost as light as hydrogen."

CHICAGO "EL" — "There is now in process of construction an electric elevated road in Chicago. . .With a track carried on an open-hearth steel elevated way, with plate girders throughout, built upon land owned in fee simple by its projectors, except for street crossings, and operated by the most advanced electric system of propulsion, the road will occupy a unique position. The entire length of the road is nearly 18 miles. . . A view of the electric generating plant



is given in one of our illustrations. The immense generators are of the multipolar type and are direct driven, the armatures being on the main engine shaft. They are of the type built by the General Electric Company especially for street car work. . . The engines are Allis Corliss, and are compound inverted vertical, direct acting, standing some 50 feet high with 25 foot flywheels."

ASBESTOS — "The uses of asbestos are almost innumerable. Ground fine and combined with colors and oils by a secret process, it makes a beautiful paint, which is said to go far toward fire-proofing the surface to which it is applied. Various kinds of roofing are also made by treating strong canvas with a combination of asbestos and felt and backing it with Manila paper. It is extensively used for roofs of factories, railroad shops, bridges, steamboat decks and other places where there is danger of fire."

HUMAN HORSEPOWER — "A French scientist has recently made some experiments which show the amount of force developed by some of the bicycle experts in a hard race. Windle and Zimmerman have maintained for two minutes a speed to continue which required the expenditure of energy representing two-thirds of one horse power. For six seconds they were able to exert the astonishing force of one and a fourth horse power."

AMERICAN MECHANICS — " 'Regarding the comparative skill of mechanicians. . . American, French, British, Spanish, German. . . it would be impossible for me to mention one nation that excels in everything. Each nation has its own peculiarities and its own specialties. . . I should say that the New Englanders are the finest mechanics in the world. I think any one who has investigated the subject will have to admit this. The tools which are designed and made in New England are incomparably ahead of those made in any other country. There is nothing in Europe that can at all compare, for instance, with the tools made by Brown & Sharpe, of Providence, R. I., Pratt & Whitney, of Hartford, Conn., and the American Tool Company, of Boston.'— Hiram S. Maxim."

PLATINUM — "The Ural platinum deposits in Russia are the only ones in the world, as this metal is worked nowhere else, and is known simply as a mineral finely disseminated in certain rocks. Platinum occurs in the Ural government of Perm, where it is found on various private properties and state lands. . . The metal is found in the form of alluvial deposits or platinum-bearing sands."

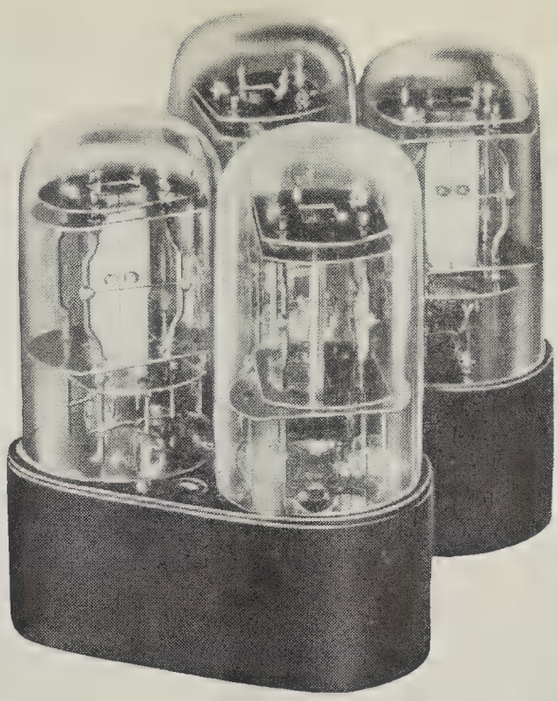
ARMOR PLATE HOLES — "The success attained of late in hardening the surface of armor plate has made it necessary to devise some especially effective method of boring holes in the plate for the bolts which are to hold it in position. . . The successful method consisted in placing the two electrodes of a dynamo current on the surface of the plate a certain distance apart, so that the intervening part of the plate completed the circuit. The plate is found to offer enough resistance to become heated, in the part selected, to an annealing temperature."

RARE METALS — "A glass case, said to be worth $50,000, was one of the attractions at the London Royal Institution recently. The contents were a variety of globules and cast bricks of unpretending appearance, used to illustrate Professor Roberts-Austen's lecture on the rarer metals and their alloys. A slab of palladium, the largest in the world, was valued alone at $35,000. . . The value of these metals, even if they could all be produced commercially on a large scale, is still doubtful, although indications of their usefulness are not wanting. Chromium, for instance, has made a revolution in steel projectiles, while aluminum threatens to become a popular craze."

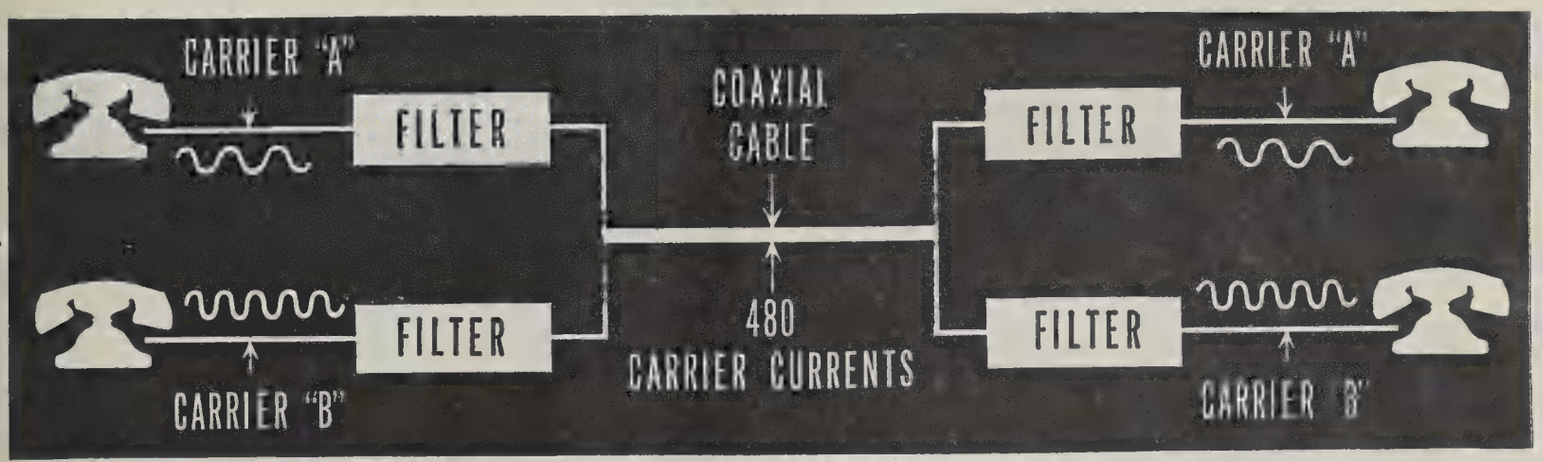
DYES — "Aniline colors were first made in France, while the tar whence they were derived was made in England. Latter the manufacture of the dyes themselves was taken up in England. Germany, however, gradually came to the fore, attaining undisputed supremacy in the manufacture in 1862. . . There was immediate and profitable employment in Germany, for all chemists who had any knowledge of anilines. About 1880, however, the supply of coal tar chemists turned out by the universities exceeded the demand for home consumption, and, the home markets becoming glutted, they turned toward America for a field."

GOLD — "A correspondent of the Mining and Scientific Press says the largest piece of gold, free of quartz, in the world was taken from the Byer & Haltman gold mining claim, Hill End, New South Wales, Australia, its weight being 640 pounds."

TRANS-SIBERIA — "Two sections of the great Russian railway across Siberia are now in operation. The aggregate of the two is 761 miles."



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Four hundred and eighty telephone conversations over a coaxial cable was one of the last peacetime achievements of communication research in Bell Telephone Laboratories. In this multi-channel telephone system, each conversation is transported by its own high-frequency carrier current. At each end of the line are crystal gateways; each opens in response to its own particular "carrier" with the message it transports. In telephone terminology, these gateways are filters.

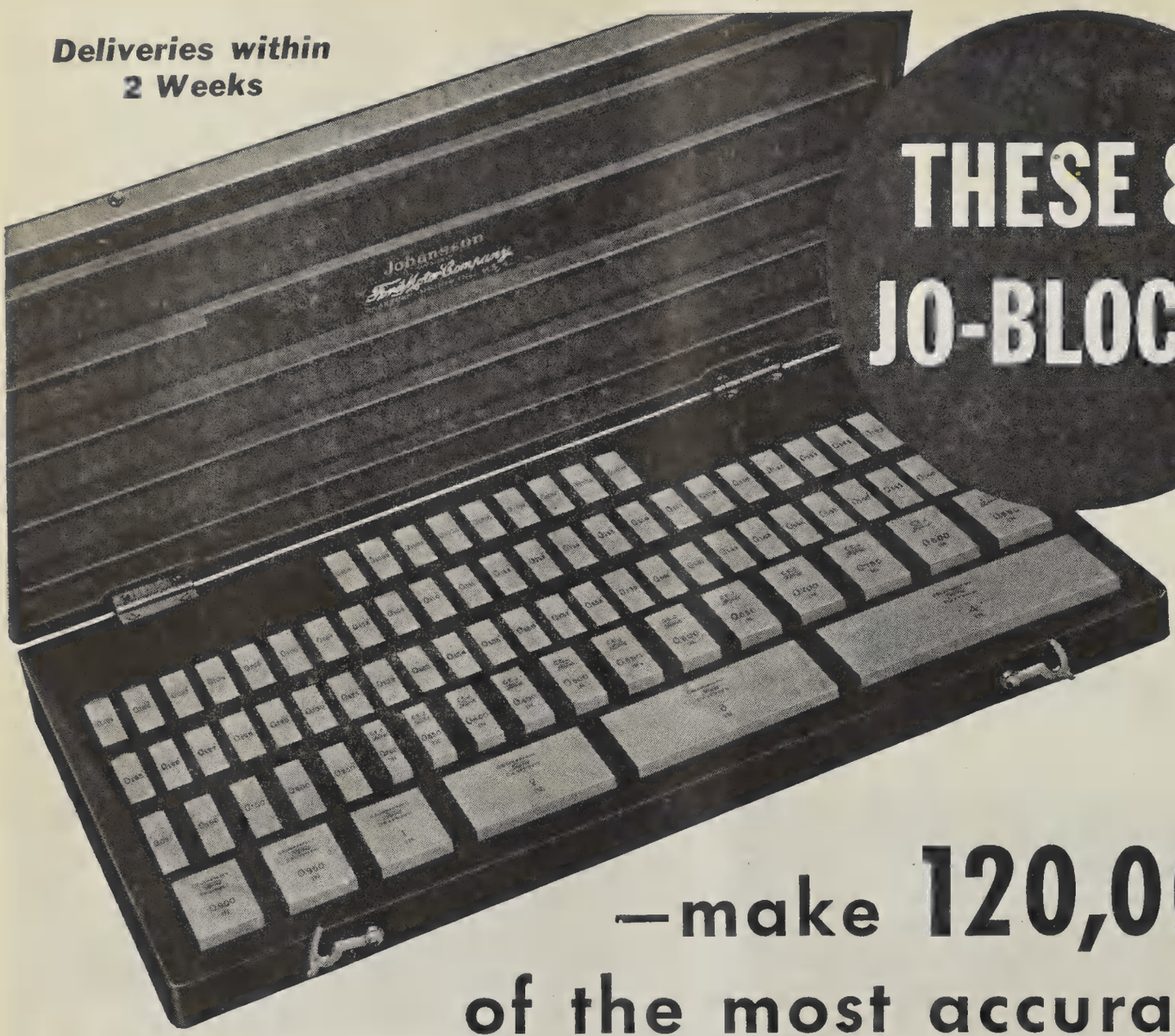
The ultra-selective characteristic of these filters is made possible by piezo-electric quartz plates, cut in a special manner from the mother crystal, and mounted in vacuum. Each set of plates is precisely adjusted so that the filter responds only to the frequency of its assigned channel, rejecting all others. In the coaxial terminal equipment, such crystal gates sort out messages for delivery to their four hundred and eighty individual destinations.

In recent years, Bell Telephone Laboratories research has provided the Armed Forces with many types of electrical equipment in which frequency is controlled by quartz crystals. Notable is the tank radio set which enables a tank crew to communicate over any one of 80 different transmission frequency channels by simply plugging in the appropriate crystal. The future holds rich possibilities for the use of quartz crystals in Bell System telephone service.

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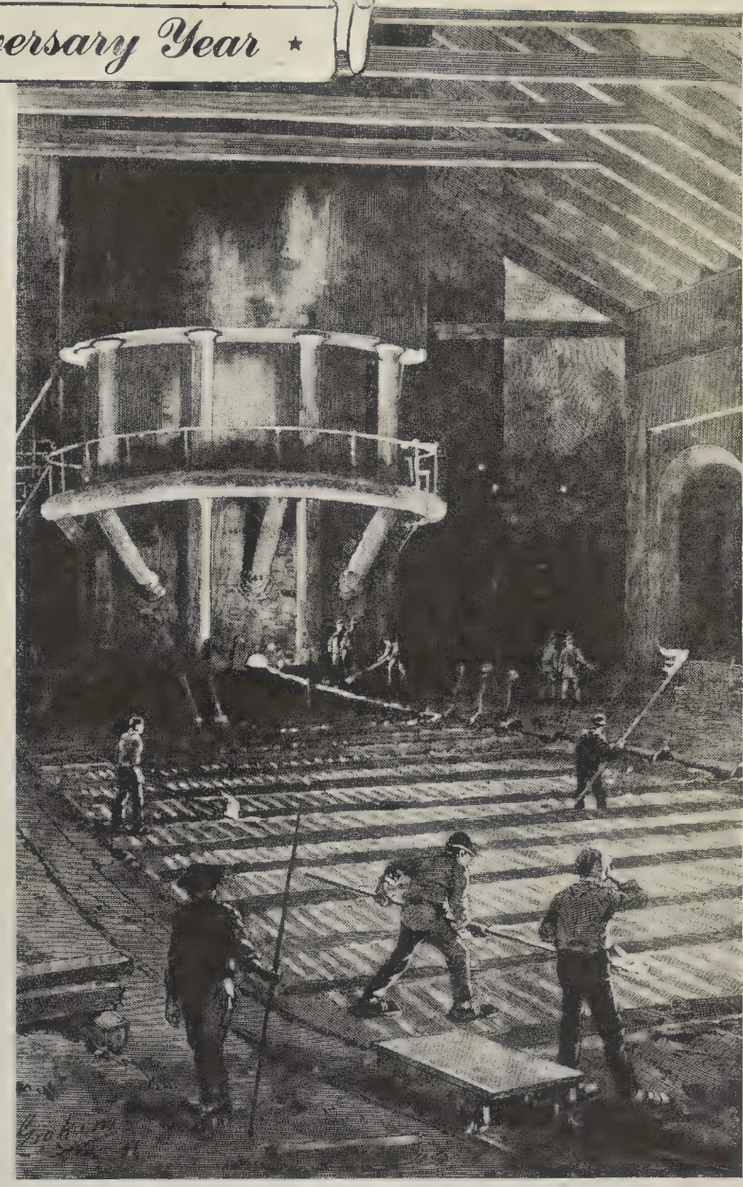
Scientific American
APRIL • 1945

* 100th Anniversary Year *

Into The Alloy Age

Agonizingly Slow Was Man's Early Development of the Use of Metals. But During the Last 100 Years, and Especially the Last 50 Years, Alloys Have Changed the Whole Picture of Metallurgy. Progress has been Breathtaking and Today Points the Way to the Unfolding of The Alloy Age

By FRED P. PETERS



Early blast furnace in Birmingham, Alabama. Illustration courtesy of American Iron and Steel Institute

ALTHOUGH many of the fields of scientific and industrial endeavor being reviewed in Scientific American's series of historical articles did not exist before 1845, this can hardly be said of metals and metal-working. True, by modern standards the world's "metallurgical" status 100 years ago was still a lowly affair but it represented a dizzying eminence in contrast with some of the positions on the long climb from Tubal Cain (seven generations after Adam and evidently the first metal-worker) up to the year this magazine was started.

For metals are literally as old as the hills and the stuff of many of them. The story of metals is indeed the story of mankind: Out of them he has made his swords and his ploughshares; their progress has profoundly affected his living and his dying; and whether he knows it or not man has mastered the metals only to leave them still in control of his destiny.

Throughout the ages power and prosperity have been the reward of those tribes or nations that possessed important metals and metal-working knowledge. Thus is modern times it is axiomatic that that nation or group of nations which dominates the world's iron and steel supply will be militarily supreme. With a steel production capacity of some 28 million tons, Germany in recent pre-war years topped all the European nations including England, and the Nazis' early military success in this war reflected not only this but the formidable total of 60 million tons of steel-making capacity which Germany attained through conquest, up to 1943. From that time, however, the full weight of America's 90 million tons of steel has been thrown against her; Germany's capacity has shrunk to some 40 million tons and the final issue is no longer in doubt.

These present-day metal-making capacities are the result of intensive scientific progress in the last 100 years. No one can say what the next hundred years in metals will unfold. But one trend is significant: For thousands of years, up to about the middle of the last century, man with agonizing slowness improved his application of *simple metals* to his peace-time or war-like needs; since that time and especially in the last 50 years he has learned something new—the production and treatment of *alloys*—and the results of that evolving technology on our whole civilization have been breathtaking. Of a certainty we have entered The Alloy Age and, because of this, life in 2045 will be as different from today's as ours is from our great-great-grandfathers'.

NINE METALS—In 1845 there were but few metals of commercial or industrial importance—chiefly iron, copper, lead, tin, zinc, gold, silver, and platinum. Before observing how they were multiplied into the hundreds of alloys that are the basis of today's engineering, let us chart the milestones along their road of progress before 1845.

Although the transition from the brass age to the iron age is generally placed around 1350 B.C., iron was anything but unknown prior to then. Tubal Cain is purported to have forged both brass and iron, and wrought-iron blades evidently made about 3000 B.C. have been found in one of the pyramids. Indeed, for many centuries the Egyptians (and the Chinese, too) seem to have been advanced in the metal-working art, especially in the making of copper, brass, and bronze implements.

We probably will never know exactly where or when iron became an important metal. The three outstanding claimants are (1) Asia Minor (the Hittites), before 1300 B.C., (2) Austria (Styria and Carinthia), about 1300 B.C., and (3) India, about 1370 B.C. (2000 B.C. according to some).

There are early evidences of the potent military influence of iron, too. Through the Hittites, iron was introduced into Assyria; the Assyrian armies were the first large forces to be equipped with iron weapons, and a single arsenal room in the palace of Sargon II, who had raised Assyria to her

greatest glory about 700 B.C., contained 200 tons of iron implements. Again, some 200 years later, the Etruscan king Porsenna defeated Rome and in his peace terms imposed one of the first "mineral sanctions"— a ban on the use of iron by the Romans except for agricultural purposes.

This wrought iron used in antiquity and up to about 1350 A.D. was produced by virtually the same process (a commentary in itself on progress over an approximately 3000-year period): mixing iron ore with charcoal and burning under a natural or forced (bellows) draft. This was the Catalan forge, and the product was a spongy mass often more than 99 percent pure (like the astonishingly well-preserved Delhi pillar of 310 A.D.) but usually contaminated with 3 to 5 percent of slag.

Pliny reports in the 1st Century A.D. that iron and steel of good quality were being made. The "steel" was produced by packing iron in charcoal and heating so that the carbon penetrated the surface of the metal and gave a hard, springy material. This is the "cementation" process, which persisted on a tiny scale into the present century. He also records that tin was used for coating both copper and iron by the hot dip process, and of course gold and silver were established items of art and commerce. Pliny's *plumbum negrum* was undoubtedly lead, for which some use existed at that time.

DAMASCUS BLADES — This was the period in which were made the fine steel swords of Damascus and Toledo and the "wootz" steel of India, produced by reducing ore with charcoal in crucibles, which warriors of the early Christian era used to advantage. By the 11th Century the martial importance of metals had reached such a point that one of the world's decisive battles—the defeat of Harold of England by William the Norman in 1066 A.D. at Hastings—went to the victor because his soldiers carried better armament. Other things being approximately equal, this has been the case ever since and is still the rule.

The "wrought-iron" period may be said to have merged into the "cast-iron" era shortly before 1400 A.D. The commercial manufacture of cast iron really began in Germany in the early part of the 15th Century, when blast furnaces were operated in Siegerland and Westphalia. These early furnaces were simply Catalan forges with extended stacks, into the tops (rather than on the hearth) of which were charged ore and charcoal, the latter in such large excess that a higher carbon, lower melting mixture than wrought iron resulted. The resulting cast iron was somewhat brittle but could be cast into shapes or used for larger articles than could be wrought. The basic metallurgy of this cast iron has not changed even to the present day, although now we know how to control and adjust it to make cast iron that is a first-class engineering material for many uses.

Immediately the Germans cast the iron into cannonballs. In 1510 Bunde, a Frenchman, and van Cullen, a Hollander, made for Henry VIII of England mortar shells of cast iron, with iron-screw fuses. These same gentlemen some 33 years later collaborated with Hogge in constructing cast-iron cannon and shells therefor.



From The Bettmann Archive

Bronze Age craftsmen casting weapons and utensils

The successful production of cast iron led to such a demand for charcoal in England, by 1600 a leading iron producer, that timber for making charcoal was approaching exhaustion and it was necessary for Queen Elizabeth drastically to restrict the production of iron. The Swedes undertook a planned planting of timber that even up to the present time has permitted them to maintain a steady production of high-quality charcoal iron. In 1619, Dudley successfully smelted iron with pit or sea coal, obtaining more iron per furnace per week than by charcoal smelting and, of course, circumventing the timber shortage. Although his process was opposed by the charcoal ironmasters and he never profited from it, he did succeed in staying in the iron business with it for some 50 years.

COLONIAL METALS — The beginning of the metal industries in America seems to have been at Lynn, Massachusetts, about 1640. Governor Winthrop built a furnace there, which by 1644 was making brass castings, and in 1645 made the first cast-iron article produced in the Colonies—a one-quart iron kettle. The Lynn furnace, which was able to smelt about eight tons of iron a week, was also the seat of the first patent granted in the Colonies—to one Joseph Jenks in 1646 for a scythe. Jenks, the manager of the furnaces, distinguished himself on several fronts in the next 20 years: He made the first fire-engine, the first dies for coinage, and the first drawn wire produced in the Colonies.



Reproduction of a copper engraving made in 1875, showing the various steps in the process of manufacturing Bessemer steel

From The Bettmann Archive

The first really good steel in America was made in Connecticut, by Samuel Higley of Simsbury and Joseph Dewey of Hebron, about 1728. In Pennsylvania the great iron industry that we know today had its small beginnings in 1716 with the Pool Forge Iron Works, three miles above Pottstown, and the Colebrookdale blast furnace, built in 1770 and also near Pottstown.

About this time there occurred one of the fundamentally important developments in the history of metals—the discovery that coke could be made from coal and that this coke could serve in place of charcoal as a reducer of iron ore. The latter invention is generally attributed to Darby, about 1713, and the first coke blast furnace was blown in by John Wilkinson in England in 1754.

There were two immediate and important results: (1) England rose to world leadership in iron production, becoming an iron exporting nation instead of an importer and (2) a need developed for means of transporting coal to the furnaces and it precipitated the beginning of the railroad industry. In turn, the railroad industry subsequently became the biggest factor in the expanding market for iron and was the impelling force behind many important quality improvements in steelmaking.

Between 1740 and 1750 there came another outstanding advance—the development by Benjamin Huntsman of a commercially successful process for making steel by fusion; the process involved placing the age-old carburized iron ("cementation steel") bars in a refractory crucible and melting them, giving a metal of homogeneous instead of irregular composition. More expensive than iron-making, Huntsman's crucible steel process gave an exceptionally high-grade material and until this century it remained the leading method for making the very best steels.

Note that the metallurgy of iron has advanced from wrought "charcoal" iron to cast "charcoal" iron to cast "coke" iron and from cementation steel to crucible steel. The steel age was dawning, though not yet here. Its advent was hastened in the 18th Century by many other developments—the invention of puddling in 1766, which improved the quality of wrought iron; the invention of the steam engine and its application to driving a slab rolling mill in 1784; and the discovery by the Englishman Mushet in 1798 that cast steel could be made directly by adding carbon to iron.

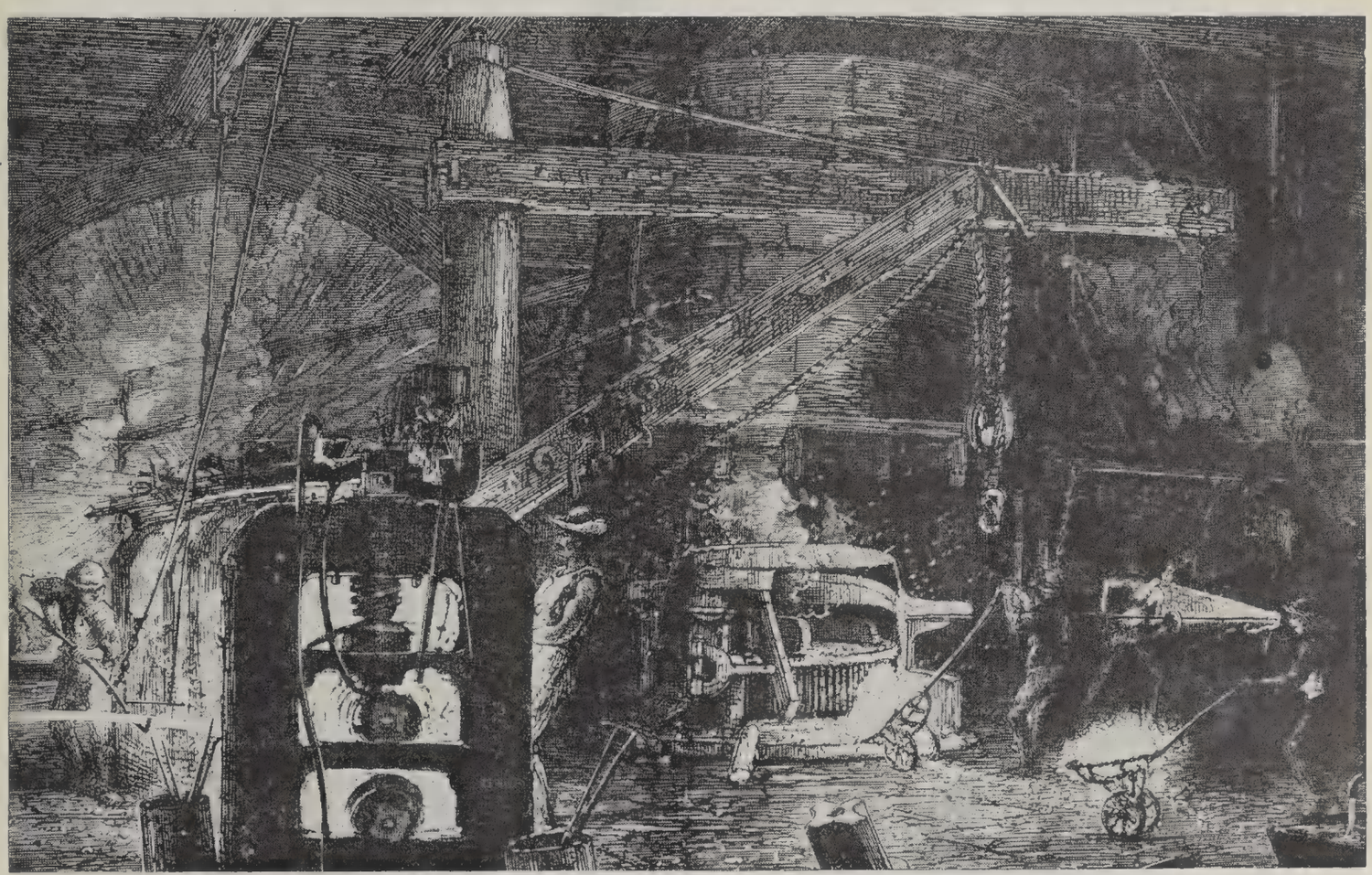
The iron industry was one of the early causes of friction between England and her American Colonies. Worried by the competition from American iron in the colonial market, the British Parliament in 1750 prohibited the refining of pig iron and the construction of rolling mills, hammers, forges, and so on, in America. The edict was ineffectively enforced, however—and fortunately so, for the developing American iron industry was a potent factor in the ultimate success of the American Revolution. Indeed it was so important as to be the basis for one of the earliest draft deferments on record —New Jersey's act of October 7, 1777, exempting from military service men to be employed at Mt. Hope and Hibernia Furnaces and reciting the necessity of providing the Army and Navy of the United States with cannon, cannon shot, and so on.

NONFERROUS PROGRESS—Although even then subordinated to iron and steel in production tonnage, the nonferrous metals hardly stood still during the 18th Century. In 1728 the French described a reversible rolling mill for making lead sheet and for rolling seamless pipe. The first Colonial copper coinage was made by Joseph Higley in 1737, and in 1750 John Allan started the brass industry of Waterbury, Connecticut. Paul Revere, a descendant of one of the owners of the Lynn furnaces, was famed as a silversmith and copper fabricator. In 1746, Dr. Roebuck of Birmingham, England, built the first lead chamber for sulfuric acid manufacture, the latter used primarily for pickling wire and other metals.

Sir Wm. Watson in 1750 first described platinum. The following year H. F. Cronstedt isolated nickel in Sweden. Another Swede, S. Rinman, discovered in 1773 that the manganese he had reduced made iron non-magnetic. Tungsten metal was isolated in 1783 by two Spaniards, J. J. and F. de Elhujar. Metallic molybdenum was successfully prepared in 1790 by still another Swede, Hjelm. The Alloy Age, still undreamed of, was having its foundations set.

Powder metallurgy, the wonder-boy of modern metalworking, probably had its beginnings in 1786 when Rochon made malleable platinum from powdered platinum. Later (1805) Tilloch produced a forgeable platinum bar by packing platinum powder inside platinum tubes and heating. It was not until 1829 that Wollaston, commonly called the father of powder metallurgy, published his important work on platinum powder.

Simultaneously with all this and obviously resulting from it had been much general engineering progress. Europe's



Interior of a steel rolling mill of about 1870. Courtesy American Iron and Steel Institute



From The Bettmann Archive

Rolling copper, about 1880

first cast-iron bridge had been built in England by Abraham Darby. The American revolutionists' forged iron chain stretched across the Hudson River at West Point had served its purpose in keeping British vessels below that place. John Fitch's steamboat in 1787 was followed by Robert Fulton's in 1807. Iron ships were made by a few builders, and in England appeared the first stirrings of what was to be Manchester's vigorous machine-tool industry from 1815 on.

From 1800 until 1845, almost breathlessly as though time were short, there were evolved the major remaining developments on which rested the transition from the metal age to the alloy age (or, if you wish, from the iron age to the steel age, for steel is an alloy of iron and carbon). In 1802 the brass button industry in America was started by Able and Levi Porter in Waterbury, using the method of directly melting copper and zinc invented by Emerson in England in 1781. In 1808 Davy attempted to isolate magnesium. By 1810 acid copper electroplating was in use. In 1811 steel was first made in Pennsylvania, by Morris Truman at Brownsville, and sold for $240 a ton. In 1812 John Stevens designed ship armor and for years continued to develop the armored ship idea with fanatical zeal.

IRON ALLOYS—Hassenfratz in 1814 studied iron alloyed with cobalt, titanium, tungsten, and chromium; in 1816 (O, unhappy day!) the Krupp works at Essen began the manufacture of steel by the crucible process. In 1820 Faraday and Stodart published a paper which may be considered the basis of much subsequent alloy development, for it described a method of etching metals to show their grain structure.

Israel Holmes in 1822 and 1831 performed the remarkable non-technical feats of purchasing in England brass-rolling machinery not supposed to be sold to Americans and then smuggling into this country several British workmen to operate his expanding plant. By 1836 rolled brass clocks had created a heavy demand for sheet brass, "nickel silver" rolling had been introduced, and the "battery" process of fabricating brass was started.

In 1826 Seth Boyden started making "malleable" cast iron in Newark, New Jersey. The first passenger railroad charter in this country was granted to the Baltimore and Ohio; by 1830 there were still only 23 miles of steam railroad in this country. In 1832 Baldwin Locomotive Works built its first locomotive, "Old Ironsides," largely out of wrought iron.

About this time there appeared another important milestone in the march of steel—the invention of the hot blast for blast furnaces by J. B. Nielson of Glasgow in 1828. The hot blast reduced the coke requirements and substantially increased the output of blast furnaces to which it was applied. The first practical use of the hot blast in America was made at Oxford Furnace, New Jersey, in 1834.

The Dane, Oersted, prepared some aluminum in 1825 and in 1827 it was produced as a fine powder by Wühler. Pure magnesium was obtained by Bussy in 1830, the same year in which Osann described one of the earliest uses of powder metallurgy—the pressing of copper, silver, and lead medals from their powders. The British platinum industry was started, on a powder basis, by Johnson and Cock, and remained a powder-metallurgy industry until Deville applied the oxy-hydrogen torch to the melting of platinum in 1859.

Zinc production, now a great American industry, may be said to have been conceived in 1835 when the Bureau of Standards, seeking a highly accurate set of brass standards for weights and measures, commissioned F. R. Hassler to produce zinc and brass of the required purity, which he did by setting up a small zinc distillation plant at the Arsenal in Washington.

In 1842 Serrell operated a continuous mill for rolling lead, copper, and iron pipe and on it was rolled the copper wire employed by Morse for his first telegraph line, from Washington to Baltimore, in 1844. In 1843 R. Boettger had described nickel electroplating and the English process of making seamless brass tubing had been invented and was being introduced in America. In 1844 was made one of the most important geological discoveries of modern times—the finding of iron ore in the Lake Superior region by Wm. A. Burt, a surveyor, whose compass was being annoyingly diverted by the deposit. From that day to this a total of more than two billion tons of high-grade iron ore have been extracted from that region to make our iron and steel.

FROM 1845—One hundred years ago today, then, where did America stand, metal-wise? Compared to our primitive ancestors we were expert in the manufacture of wrought iron and cast iron on a comparatively gigantic scale (about 400,000 tons of pig iron per year in America—but compare that with today's 62 million tons), and of steel on a much smaller, specialty-product scale (less than 10,000 tons). There were about 4000 miles of railroad rails in use, mostly wrought iron or cast iron.

A few nonferrous metals—copper, zinc, tin, lead, silver, gold, and platinum were commercially important. Many other nonferrous metals were known and under close study, but as yet only promising—aluminum, magnesium, nickel,

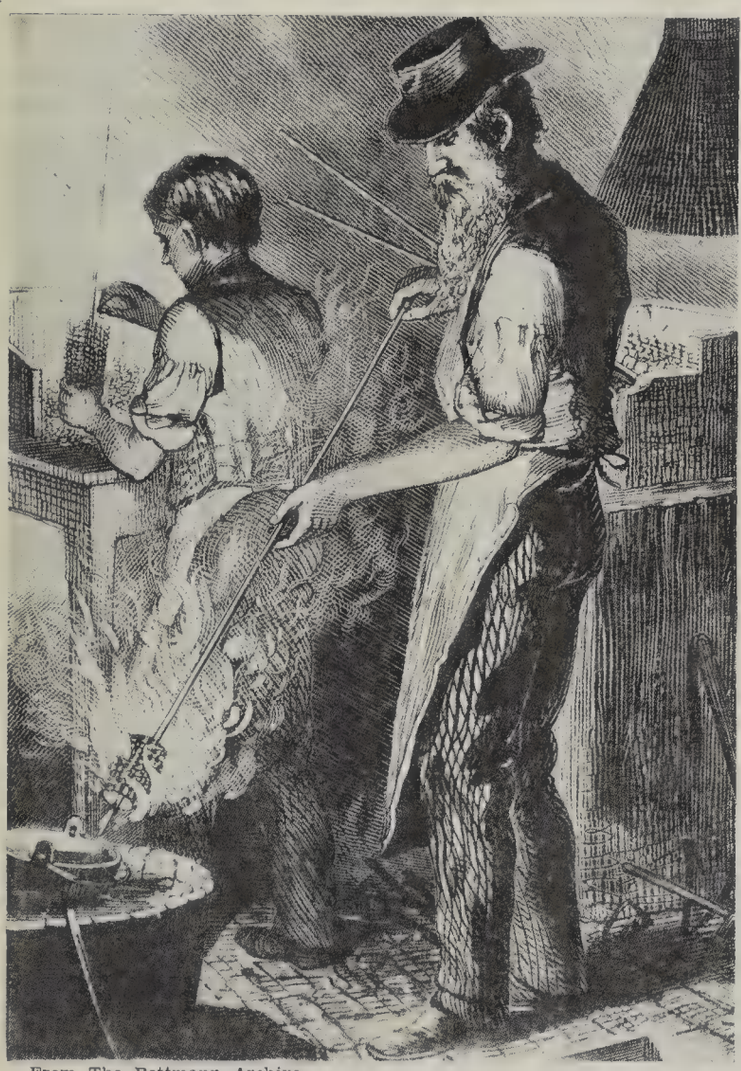
chromium, cobalt, tungsten, titanium, molybdenum, manganese, and others. We had no alloy steels or irons; indeed the only "alloys" of real importance were brass and steel, with the former more widely used. But the stage was set!

Approximately in the order of their appearance, the actors who have dominated the unfolding drama of the alloy age in these last hundred years are William Kelly, Sir Henry Bessemer, Robert Mushet, H. St. Claire Deville, Robert Bunsen, Sir Wm. Siemens, John Fritz, Henry Sorby, E. and P. Martin, Robert Hadfield, Paul Heroult, Charles Martin Hall, Capt. Wm. Jones, Henry Marion Howe, Albert Sauveur, Strauss and Maurer, Sir Harry Brearley, Elwood Haynes, Alfred Wilm, Albert Marsh, E. F. Northrup, P. D. Merica, E. C. Bain, and E. S. Davenport.

The first of these—William Kelly in America and Sir Henry Bessemer in England—were independently responsible for the invention of the so-called Bessemer converter and process for making steel, whereby molten pig iron is "blown" with air to burn out the carbon and give a relatively pure, low-carbon material. Kelly, in 1846, discovered that blowing air through liquid high-carbon iron refined it. In 1854 Bessemer, seeking an improved gun material, made the same observation. Their converters were the first mass-production steel-making units devised and were without question the beginning of the steel age that we know today.

Their vicissitudes in establishing their strikingly similar processes, both here and in Europe, represent a fascinating story all alone. Suffice it to say here that the technical problem of overcoming the brittleness of early Bessemer steel and making it harder was solved by Robert Mushet, in 1856, through the addition to the melt after the blow of spiegeleisen (high-carbon ferro-manganese). Because of these inventions, the 12,000 tons of American steel of 1860 became over 50,000 tons by 1870 and 1¼ million tons by 1880—largely Bessemer steel in the latter two cases—and the United States pulled alongside Great Britain to challenge the latter's supremacy in iron and steel production.

In 1857 Kelly patented his converter in the United States and installed his eighth converter at the Cambria works in Johnstown, Pennsylvania. At this same works and in this year John Fritz, then the company's chief engineer and manager (and later to become president of Bethlehem Steel Company), invented the three-high rolling mill, an innovation that markedly increased the productivity of our steel mills in subsequent years.



From The Bettmann Archive

Oil tempering steel springs in 1850



Charging an iron furnace in the 1870's

Also in 1857 Bessemer patented what is now known as "continuous casting" or direct rolling—the pouring of molten metal between water-cooled rolls and withdrawing solid, rolled plate from them. The process has been intensively developed within the last 15 years and is now used in the light metal and copper alloy field.

The nonferrous metals, too, were hammering hard at the gates of progress. In 1848 the Frenchman Junot patented chromium plating, and the New Jersey Zinc Company was started, primarily to make pure zinc for the Bureau of Standards' weights and measures. Hayden of the Scovills in Connecticut developed the spinning process. By 1850 dentists were using powdered nonferrous metals, chiefly silver and tin powders mixed with mercury, and a workable gold sponge made from powders.

$545 TO 14 CENTS—Aluminum took a great stride forward in 1855 when H. St. Cl. Deville exhibited the metal at the Paris exposition and Napoleon started its commercial production. In 1852 aluminum cost $545 a pound; by 1856 Deville had brought the price down to $34, and by 1859 (in which year the world production was about two tons) to $17. The price today is 14 cents a pound and American production is in the neighborhood of one million tons a year.

The step that led to the development of what is now the world's greatest metallurgical production unit—the open-hearth furnace for making steel—occurred in 1856 when Sir William Siemens patented in England the regenerative heating principle as applied to furnaces. In 1864 two French brothers, E. and P. Martin, with Siemens's help, succeeded in producing steel in a regeneratively-heated open-hearth furnace, which is the reason that most of Europe today calls open hearth steel-making the Siemens-Martin process.

The first open-hearth steel furnace in America was installed by F. J. Slade at Cooper Hewitt's Trenton works in 1868. In 1870 the annual production of American open-hearth steel was about 1300 tons—approximately 1.9 percent of our total steel production of 69 thousand tons. Today, open-hearth steel represents 88 percent of a total steel ingot production of some 90 million tons.

A steel item of commercial importance in 1857 was crinoline wire, which was tempered continuously and of which some 1500 tons were made in that year. In 1858 the first transatlantic cable was laid, using 22-gage charcoal iron wire. In the same year the brass manufacturers adopted what is now the American Standard or B. and S. wire gage.

Joseph Wharton began making zinc at Bethlehem (the Lehigh Zinc Company) and in 1860 American zinc production amounted to 800 tons; today it is nearly a million tons and of incomparably higher quality. In 1864 Joseph Wharton also began the manufacture of nickel at Camden, New Jersey.

A significant (though at the time unappreciated) development of 1863 was Henry Sorby's use of the microscope for

studying the structure of metals. The application of this tool and the science of metallography based upon it have been primary factors in our modern understanding of the nature and behavior of alloys and in our development of new alloys. Sorby was the first of a procession of distinguished metallographers that included Tschernoff in Russia, Roberts-Austen in England, Henry Marion Howe in America, Osmond in France, Brinell in Sweden, Stead in England, Rosenhain in Australia, and Sauveur in America—all long since passed away—in addition to a few living men whose actual contributions cannot yet be dispassionately appraised.

Magnesium had its commercial conception in 1869, when the German chemist, Robert Bunsen, produced it by electrolyzing a fused bath of anhydrous magnesium chloride in a porcelain crucible. The only use for the metal at this time was for photoflash powder and pyrotechnics generally. Gwynn in 1870 gave powder metallurgy a push forward by pressing tin powder with oil to form journal linings—probably the first self-lubricating bearing.

Engineering developments of this period that stemmed from progress in metals included the development of the motor-generator by the Siemens brothers; the growth of the American railroad industry and completion of the first transcontinental line; the demonstration by the Prussians that chilled cast iron had remarkable resistance as armor plate; the founding of the American Institute of Mining Engineers; the erection at the Cramp yards of the first iron ships for transatlantic passage; and the replacement of iron by steel in Pennsylvania Railroad axles and in horseshoes.

By 1870 American pig-iron production had skyrocketed from 820,000 tons (in 1860) to 1,865,000 tons, with a third of the product going into iron rails. Bessemer steel rails were making impressive inroads, however, and in 1872 the iron rail reached its installation peak (about 800,000 tons), declining thereafter to the vanishing point early in this century. Steel (mostly Bessemer) passed iron as a rail material in 1876, the quality and availability of Bessemer steel rails being a leading factor in the astonishing growth of our railroad system in this period.

COMMERCIAL INVASION—In 1875 American iron and steel products invaded the British market. From then until 1889 America and England were neck-and-neck in the race for iron and steel supremacy. The pattern of the 20th Century, with America the world's greatest industrial and (if necessary) military and naval power, was beginning to take shape.

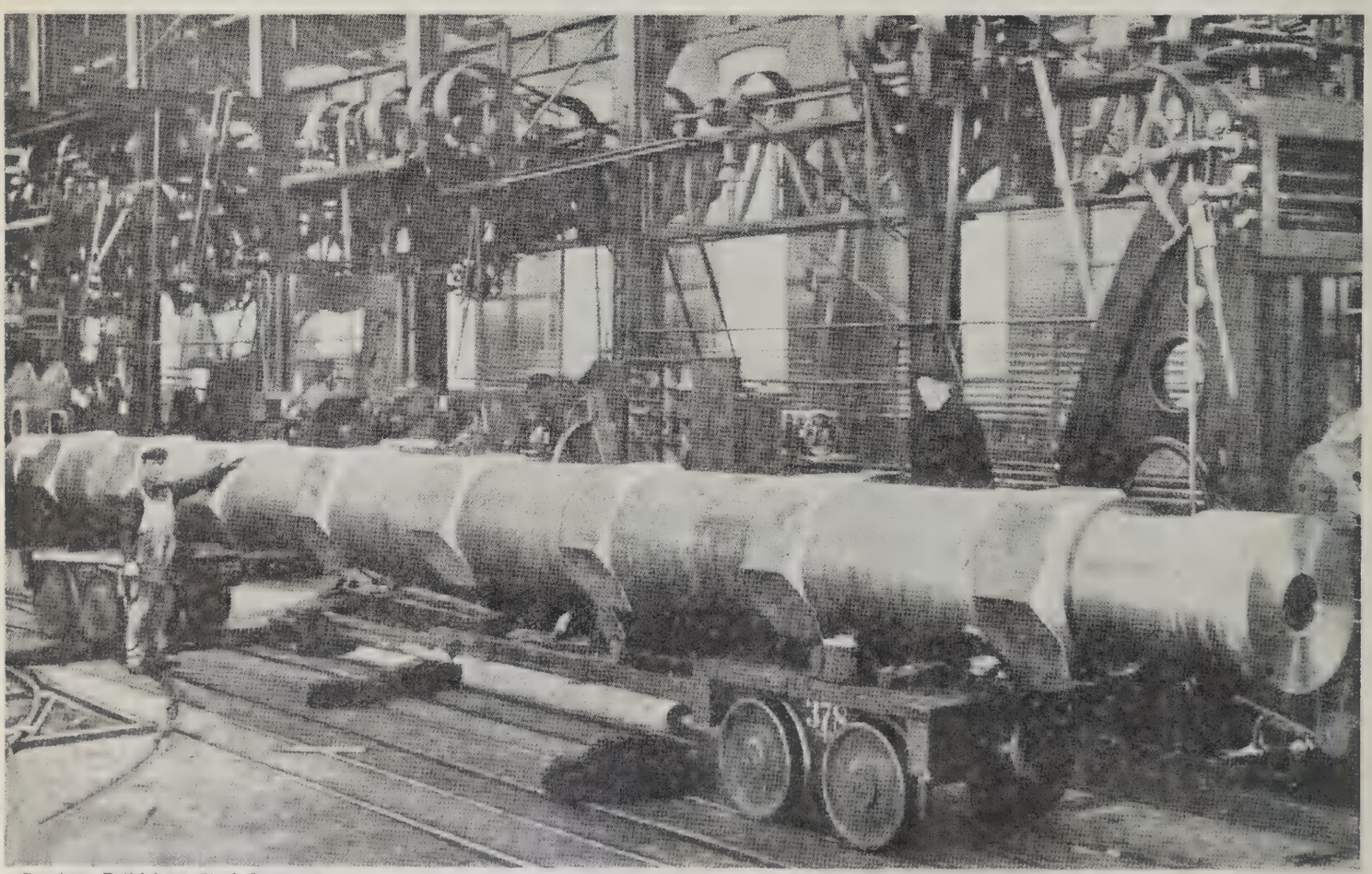


Courtesy American Bridge Company

One of the first single-phase Heroult electric arc furnaces built in the United States in the early 1900's

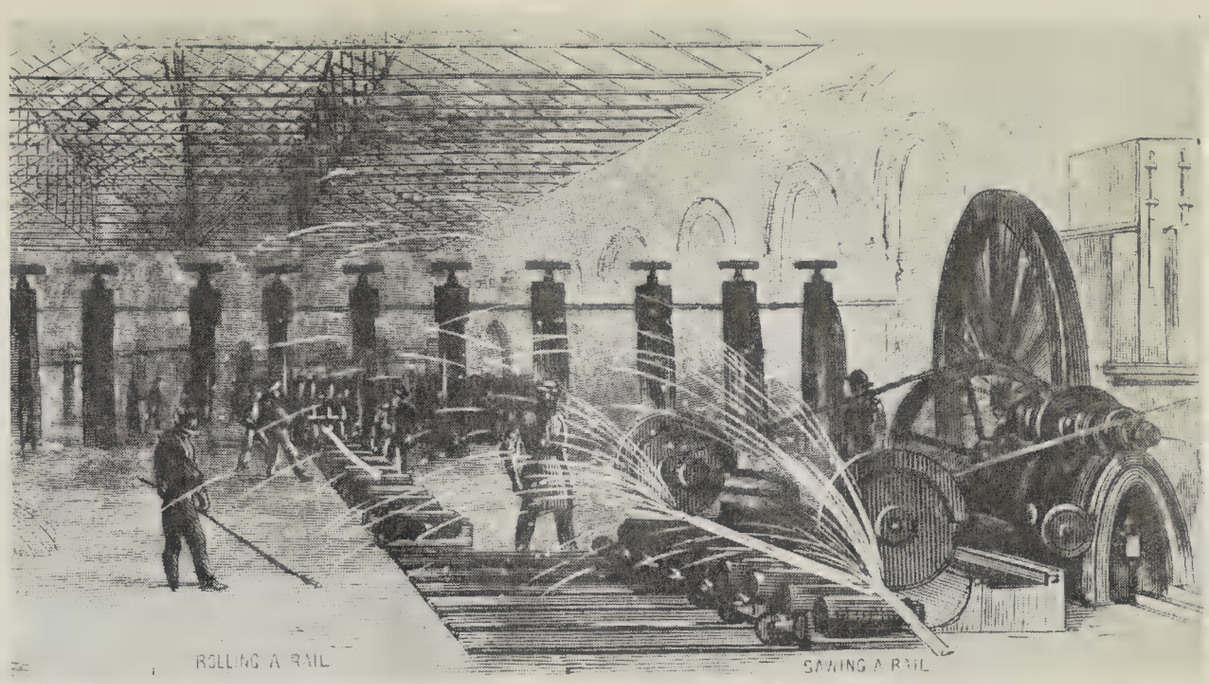
The steps in this race were closely spaced. In 1873 Carnegie, McCandless and Company, later the Edgar Thomson Steel Works and the nucleus of today's United States Steel Corporation, was formed. Carnegie hired Capt. William Jones as his manager, and Jones is now recognized as having been one of the greatest production managers of all time, developing as he did the hot metal mixer and introducing numerous technical and labor-relations innovations that brought the output of a typical blast furnace from about 525 tons a week in 1873 to more than 1500 tons at the time of his death in 1889. Typical evidence of his production genius was the fact that in 1876, three years after its inception, his plant was producing more steel rails than the entire industry made in 1870.

In 1877 S. G. Thomas and P. C. Gilchrist in England developed the basic refractory lining for steel furnaces, thus



Courtesy Bethlehem Steel Company

First hollow-forged nickel-steel shaft for a stern-wheel steamer, made in the late 1890's



Rolling and hot-sawing rails, the steel industry's first great product, in about 1875. Illustration by courtesy of American Iron and Steel Institute

permitting the refining of pig-iron containing high amounts of sulfur and phosphorus and vastly extending the utility of the steelmaking process. The year 1879 saw fast development of basic practice, especially in Germany. The Germans set up a high protective tariff and began the intensive development of their iron and steel production that brought them to the world's Number 2 position in this respect before the present war.

At about this time the telephone was being readied for practical use, Edison was introducing his incandescent lamp, and Otto his four-cycle gasoline engine. New Caledonia was now the Number 1 nickel producer. St. Mary's Ship Canal, chiefly by virtue of its iron ore traffic, was fast becoming one of the most important waterways in the world and by 1885 had surpassed the Suez Canal in annual tonnage passed.

In 1878, Sir William Siemens made the first electric melting furnace and in 1882 successfully melted 20 pounds of steel in an electric unit. This was a major step toward the development of the alloy steel industry, which subsequently depended heavily on the electric furnace for production. Another step was the invention by Robert Hadfield in England of "manganese" steel. Although important, Hadfield's steel was not the first high-alloy steel, for the latter honor undoubtedly belongs to Mushet's tool steel, developed in 1857 and containing 7 to 12 percent tungsten with carbon and manganese.

In 1886 Paul Heroult patented his electric melting furnace and put that development on a commercially practical plane. There was much metallographic research activity, and in 1888 Henry Marion Howe described the essential constituents of steel and christened them pearlite, ferrite, and cementite. Krupp's at Essen had become the world's largest steel plant but America was the greatest iron- and steel-producing nation, to the tune of nine million tons of pig iron a year.

ALUMINUM STEPS OUT—The light metals, now major materials and very much in the public eye, enjoyed the most important of their early commercial developments just before 1890. In 1886 Charles Martin Hall, a 22-year-old student at Oberlin College, Ohio, succeeded in producing aluminum by dissolving alumina in molten cryolite and electrolyzing the bath. This process, on which was built the aluminum industry of today, was independently discovered in France in the same year by Heroult, in one of those astonishing coincidences of which the history of science is so full. In 1888 Hall became one of the founders of the Pittsburgh Reduction Company, forerunner of today's Aluminum Company of America.

Also in 1886, the Germans started producing magnesium at the Wintershall-A. G. in Hemelingen, using a modification of Bunsen's process mentioned earlier. Ten years later the Elektron works at Bitterfeld, Germany, employing a process similar to that used at Hemelingen, began large-scale production of magnesium and Germany remained easily the world's largest magnesium producer until 1942 when this country not only surpassed Germany in that respect but actually dwarfed the German output—with about 75,000 tons of magnesium to the German's 25,000.

The tinplate industry came of commercial age around 1890, with the passage of the McKinley tariff. Bethlehem Steel Company made armor plate for the United States Navy and the first pieces of "Harveyized" (face-hardened) armor plate were proof tested. Mond patented carbonyl nickel in 1891, starting the nickel industry on its road to greatness. In 1894 E. L. Frisbie imported into America the method and machines for making seamless tubing by the Mannesman process and two years later the brass industry earnestly tackled the problem of making extrusions—a problem that took years to solve completely but whose solution early in the 20th Century was one of the most important developments in copper and brass technology.

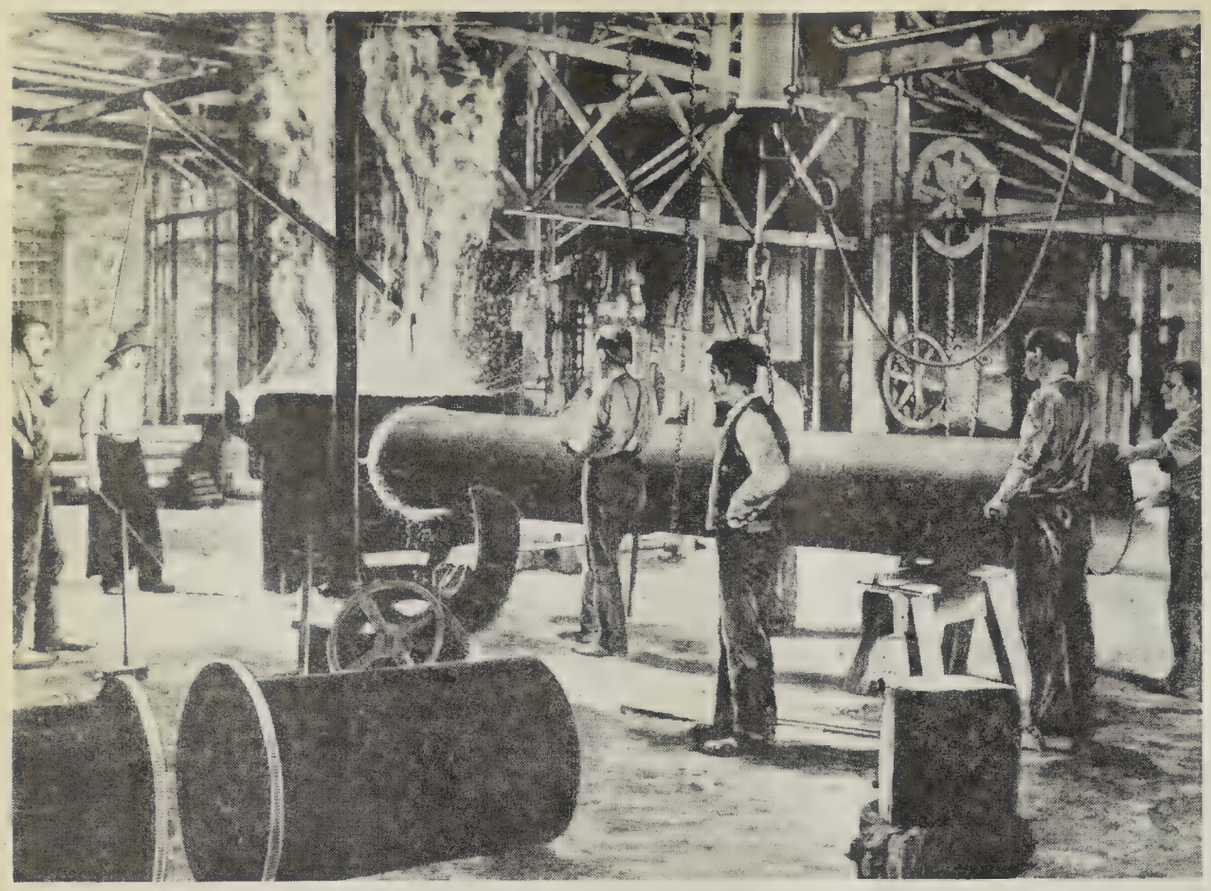
Dr. Langley's aerodrome flew in 1896 and seven years later the Wright brothers' flight near Kitty Hawk, in a plane with an engine weighing 21 pounds per horsepower, completed the stage-setting for an industry that was some 40 years later to be America's greatest and the chief market for over a million tons of the new light metals. And because of the light metals and strong steels used in their construction, today's aviation engines weigh only one pound per horsepower.

The last years of the 19th Century were years of merger and expansion. The leading wire producers affiliated to form the American Steel and Wire Company, while Carnegie and his associates developed a vast system of from-ore-to-finished-product steelmaking. This trend carried into the new century, and in 1901 the billion-dollar United States Steel Corporation was formed. American pig iron production shot up two million tons in each of the next two years.

TOOL STEELS — Outstanding developments of these years were the discovery by Frederick Taylor and Maunsel White (of Bethlehem Steel Company) of high-speed tool steels containing tungsten, chromium, carbon, and manganese, and of heat treatments for them that permitted cutting metals at speeds that heated the tool red hot. These steels and their use were demonstrated at the Paris Exposition in 1900, and literally revolutionized the art of cutting metals from that time on.

By 1900 there were 250,000 miles of rails in America, of which over 90 percent were steel. New steel rails were [illegible] percent the Bessemer product, despite the fact that a third of our total steel production was now made in the open-hearth. But traffic was so heavy on the rails and wear so serious that about this time the railroad industry urgently besought the steel industry for better rails. The result was an astonishing jump in open-hearth rail production from 1333 tons in 1900 to 1,751,360 tons in 1910 and a drop in Bessemer rails from 2,380,000 to 1,884,000.

Thus began the real rise of open-hearth steel in America. From this point on open-hearth steel developed its own



Welding a flange on a 22-inch steel pipe in 1897. The end of the pipe and the flange were placed in a special gas-fired furnace built in two semicircular halves, the upper one of which was removable. The welding-up was then completed on a concave anvil. Illustration reproduced from Scientific American

markets, rising in 40 years to a peak production of over 70 million tons while Bessemer steel climbed slowly to five million tons in the same period.

In the nonferrous field 1902 found leadership in nickel production going to Canada, a position she has since maintained. In 1904 Just and Hannaman patented tungsten filaments, made from the powdered metal and a binder. Coolidge in 1909 obtained his patent on thoriated tungsten, which became the basis for the electric lamp industry and later of the electronic tube.

The brass industry in 1908 began investigation of hot pressing and by 1914 had succeeded in developing this technique to one of major importance. Notable changes were occurring in the precious metal field, too. Up to this time jewelry metals had been chiefly gold and silver with copper and zinc added. Now platinum came in for both jewelry and dentistry and by 1915 platinum and its cousins palladium and iridium had become the royalty of the jewelry field.

Electric steel melting continued to increase in importance. The first Heroult electric furnace in an American steel plant was installed at the Halcomb Steel Company in 1906. By 1909 there were 105 electric furnaces in the world, 10 of them in the United States, and in 1915 American electric furnace steel capacity was nearly half a million tons a year. From that time on the United States' electric furnace steel capacity remained the world's largest.

HEATING ELEMENTS—A 1906 development of indirect but profound importance in the development of modern metallurgy was the invention by A. L. Marsh of the 80-nickel 20-chromium alloys possessing superlative heat resistance and high electrical resistivity. Originally applied as a heating element material, Marsh alloy was modified by himself and others to be the basis for wrought and cast heat-resisting materials that found immediate and growing applications for pots, burners, muffles, conveyors, and other parts of heat-treating furnaces. The existence of these alloy castings has made possible the modern mechanized, close-control heat-treating furnace without which American steels would not have the properties they do today and without which, indeed, full utilization of the National Emergency steel program would have been impossible.

About 1912 activity started in at least three countries that led to the development of the materials that we know today as stainless steels. In Germany Strauss and Maurer developed and patented high nickel-chromium steels on whose mechanical properties, corrosion resistance, and metallography they reported in detail in 1914. Almost simultaneously Sir Harry Brearley in England, while studying gun steels, discovered the remarkable corrosion resistance of the plain chromium steels of the type now used for cutlery and related uses.

In America Elwood Haynes had experimented with the cobalt-chromium and cobalt-chromium-tungsten alloys that we now know as Stellite and he patented these in 1913. This work led him to study the properties of the straight iron-chromium alloys and he must share with Harry Brearley some of the credit for independently discovering the corrosion resistance of the iron-chromium alloys.

The first strong aluminum alloy, progenitor of several which now form the sinews of the world's war planes, was invented by the German Wilm. It was an alloy of aluminum, copper, and manganese, which he called Dural or Duralumin and which we know in this country as 17 S. The high strength of the alloy, hitherto unknown in such light materials, was obtained by heat treatment but the further development of this idea in the light metal field had to wait until 1922 when Merica, Waltenberg, and Scott published their paper explaining why Wilm's alloy could be heat treated and promulgating the metallurgical doctrine on which was based the development soon thereafter of many other heat-treatable nonferrous alloys.

HUNDREDS OF IMPROVEMENTS—Since World War I, progress in alloys and in metal processing has come not as a few fundamental and long steps forward, but as hundreds of commercially important small improvements covering the whole field of metallurgy. Thus, the World War I years saw the steel industry just about double its capacity. Magnesium was first produced in America in 1915, The Dow Company starting its operations a year later. By 1918 there were five manufacturers of magnesium, of whom only two survived the post-war period.

In 1923 the American Rolling Mill Company installed the first continuous sheet mill in this country and by 1926 several companies were using continuous rolling for the production of hot and cold rolled strip steel. The development of these mills unquestionably was an important factor in the subsequent expansion of the automobile industry; the steels provided a low-cost, workable, strong auto body material on a mass-production scale and filled perfectly one of the greatest needs of the automobile manufacturers up to that time. The cold rolling process also drastically improved the quality and uniformity of tinplate, making possible much better tin cans at lower cost than before.

In 1922 and 1923 the behavior of molten magnesium was systematically studied. Sulfur and boric acid were shown to inhibit the oxidation of the liquid metal and this permitted casting magnesium in green sand molds. By 1925 Dow had developed its fluid flux, all these advances constituting as a group the basis of the magnesium casting industry as known today.

In 1924 Colin G. Fink developed successful commercial chromium plating and opened up an entirely new field of materials engineering. The automobile industry quickly adapted bright chromium to its styling needs and American automobiles became famous for their "luster."

In 1927 the Krupp laboratories devised the method of bonding tungsten carbide powder with cobalt to make extremely hard tools and dies. Cemented carbides were rapidly adopted in this country and in England and have been responsible for two revolutionary changes. The first was an increase in the speed of machining most metals (recently including steel), and the second was the introduction of tungsten carbide dies for wire drawing, replacing tool steel dies for larger sizes and cutting into the diamonds for some of the smaller sizes.

The science of steel treatment was pushed ahead significantly in 1930 when E. S. Davenport and E. C. Bain published their research on the constant-temperature transformation of steel as distinct from the conventional quench and temper process. This has lead to an entirely new approach to heat-treating problems and to the development of new treatments that have immeasurably advanced this important art.

In the early 1920's less than 20,000 tons of high-grade zinc were used for die castings. Today zinc die castings are employed to the extent of about 100,000 tons. Aluminum and magnesium die castings are growing in importance too—both of them leaders in a parade toward precision fabrication of metal parts, either by casting or by solid-working methods.

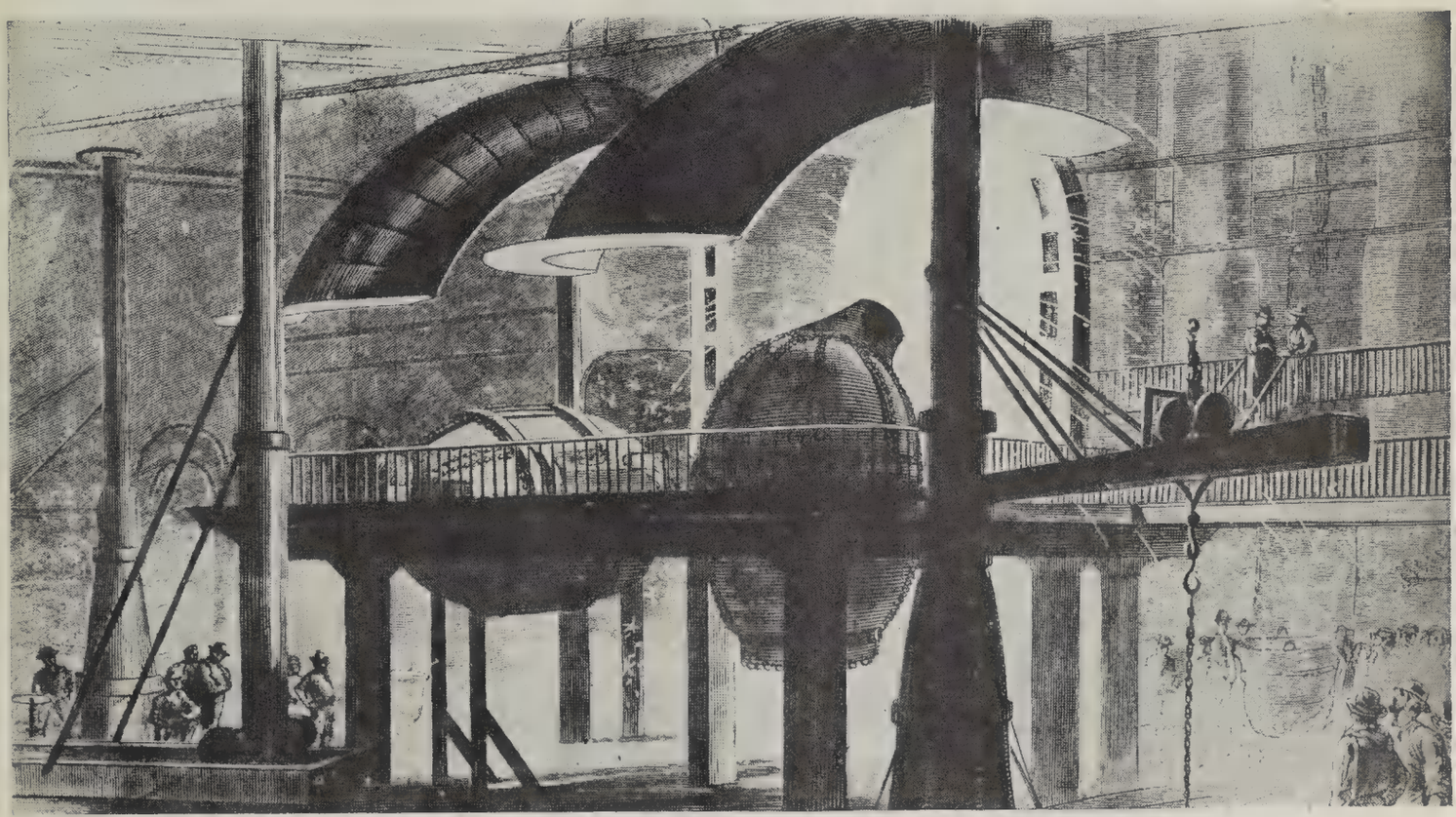
HIGHER PRECISION—Indeed the outstanding characteristics of the present period, with respect to metals and alloys, are this tendency toward greater precision of metal products, the development of metals of ever higher purity, the formulation of alloys of continually better properties, the application of modern knowledge of the microstructure of metals to their practical processing and fabrication. Some of the most recent of these specific advances were described in Scientific American for January. Many others are still under wraps until the defeat of our enemies.

Of them all the most important is unquestionably the emergence of the series of metals that is based on the specialized properties of myriad *alloys*. Where once there was iron we now have not just "steel," but steels galore. To copper and brass have been added countless brasses and bronzes containing—in addition to copper and zinc or tin—aluminum, silicon, beryllium, manganese, nickel, lead, chromium, and others. Zinc, lead, tin, nickel, aluminum, and manganese have themselves graduated from the simple "metal" class to become the parents of numberless alloy series based upon each of them.

These trends, the salvation and power of America at war, will be the basis for the industrial activity and general well-being of America at peace. For the lessons of history should teach us not only that we must, for strategic reasons, maintain the growth of our metal industries between as well as during wars, but also that developments in the creation, fabrication, and use of alloys snowball in number and importance in our peace-time life with each passing year. Metallurgically, America's future is bright indeed.



Charles Martin Hall, aided by his sister, discovered an inexpensive process for making aluminum in 1886. From a dramatized movie version of this highly important discovery, "Unfinished Rainbows," presented by the Aluminum Company of America



A general view of the Bessemer converters in a steel mill of the 1870's

Engineering Thinking

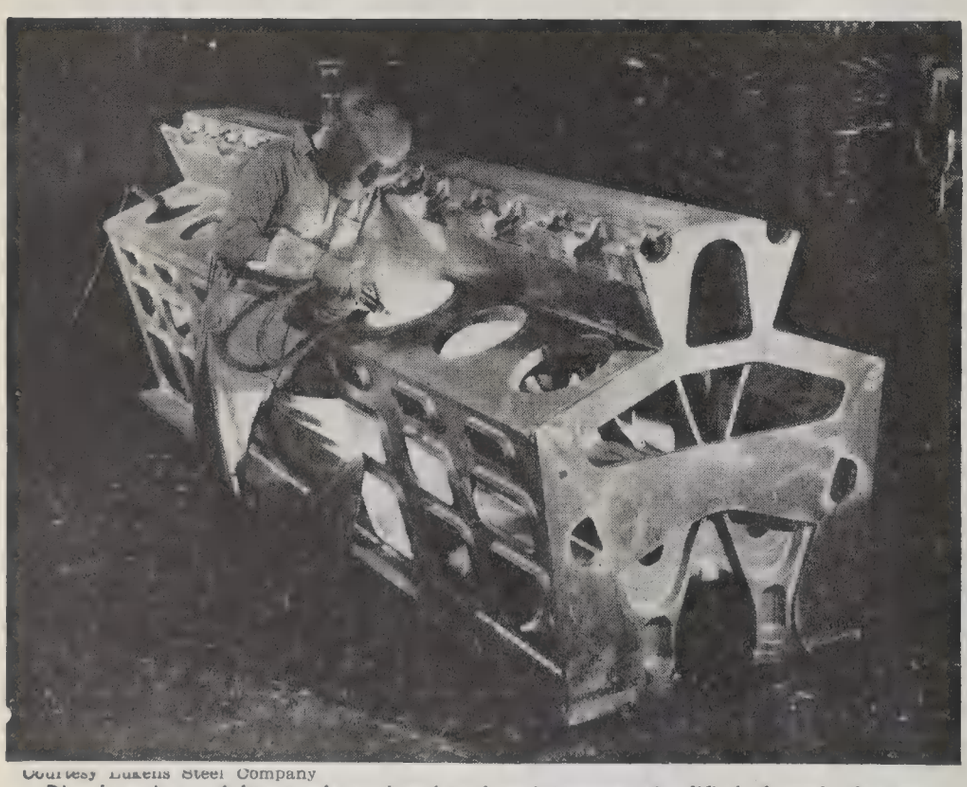
Automotive Engineers Shun Discussion of Post-War Automobiles, But Point Significantly to Such Developments As Redesign for Lightness, Multiple Power Plants, Air Conditioning, Power Steering, and the Increase in the Life of Cars. In the Meantime, They Work Day and Night on War Orders

UNDERLYING all other reasons why the automotive industry has been superlatively successful in manufacturing weapons of war is the long tradition of yearly automobile model changes. A recent survey of engineering thinking in the Detroit area disclosed no apprehension that secret projects underway at hell-bent speed would fail of achievement, and no doubts were expressed that production "impossibilities" would be overcome in the automotive industry's usual stride. After a series of conferences with dubious Government spokesmen in Washington, few of whom even understood the intricacies of mass production or the weapons under discussion, the Detroit peregrination was refreshing.

Ingenuity, the linguistic root of our word *engineer*, is one of the symbols of the American way of life. Stemming from the desperation of our immigrant forefathers and fostered by their fights for bare existence on the frontiers of new territories, ingenuity has developed to a degree that amazes Europeans and even occasionally gives pause to American engineers themselves. This is the background to the arsenals of democracy, as well as the background of the post-war automotive engineering to come.

In scores of off-the-record interviews, engineers shied away from discussion of the post-war automobile. Their intense interest in licking the task at hand in the shortest possible time was assurance enough, for this writer at least, that the motorist may look forward to improvements beyond the average expectation of things to be.

Unfortunately, those interested in specific engineering developments must wait until after the war for detailed disclosures. The extreme censorship view taken by some of our military leaders is that even hints might aid and abet the Axis scientists and engineers working for our defeat. But some of the work already disclosed may serve as a guide to thinking of the future, even if it does not form a precise mosaic. There is no borderline between automotive and armament thinking today. Peace-time developments made mobile weapons a fact, and military engineering developments, being made jointly in many cases by Army, Navy, and civilian engineers, will have an important function in post-war automotive advances.



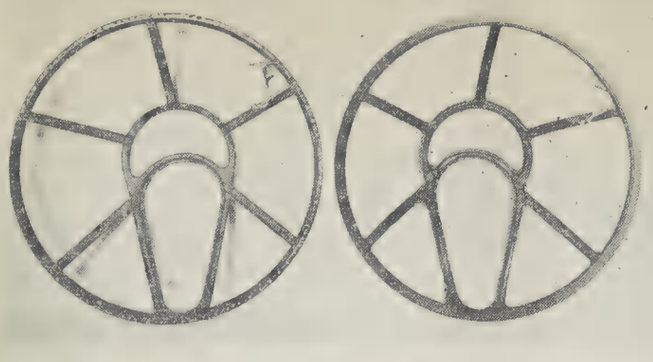
Courtesy Lukens Steel Company

Diesel-engine weight can be reduced and maintenance simplified through the use of welded steel plates, rails, and forgings in fabricating the crankcase. Illustrated is a 2000-horsepower Diesel frame being constructed in a plant of Lukenweld, Inc., from parts flame-cut and formed by By-Products Steel Corporation

MULTIPLE ENGINES — As an example, the multiple engine idea is seen today as an important post-war possibility for trucks and buses. Several engineers presented this idea at the recent War Engineering-Annual Meeting of the Society of Automotive Engineers in Detroit. One pointed out that two engines of 150 horsepower each, properly installed, would outperform the average 175 horsepower motor-coach engine in every respect. Only one engine would be used by the driver when but one was needed, and the other would be held in reserve for highballing. Another engineer at the same meeting showed that as high as 50 percent savings in power-plant costs could be achieved, cited substantial weight savings, and pointed out that engine failures on the highway could be almost completely eliminated.

Light-metal advocates were given food for serious thought when another engineer told a large meeting that steel parts had frequently replaced aluminum and magnesium units at a saving of weight and cost and had proved to be of greater strength. Case after case was cited, together with design details and manufacturing cost figures, to show that a great deal was yet to be learned about the proper selection of materials. Thus the extensive participation of non-aircraft manufacturers in the nation's huge airplane program again proved that, like lightning, one can never tell where a good engineering idea will strike next.

This thinking follows that which fostered the Navy's current project of using welded rolled steel plates, rails, and steel forgings to build up a huge Diesel-engine crankcase to reduce weight, increase the speed of manufacture, eliminate rejections entirely, and to simplify maintenance immeasurably. A few years ago steel castings constituted the only known method of manufacturing units of this character, but



Paradoxical as it may seem, steel was substituted for magnesium in this B-29 bomber nose frame to save weight. The new welded and pressed steel frame is at the left and the obsoleted cast magnesium frame at the right

Courtesy A. O. Smith Corporation

the engineering thinking of a small and aggressive steel mill broke a serious bottleneck for the Navy. Already, welded steel plate structures are competing with castings for many purposes.

POWER STEERING—Automotive engineers expect to lean heavily upon the experience of military equipment in future development of power steering for trucks, buses, and the larger passenger cars, just as the Army and Navy engineers adopted vacuum, hydraulic, and compressed air power boosters from other applications in American industry. Here again the line of demarcation between weapon and peace product engineering is faint and at times invisible.

Immediate demands for improved power devices brought about a coördinated workout of the best brains of the military engineering staffs and prime and subcontractors. Engineering thinking from coast to coast was activated on this project. Again, contributions were made by university faculty members versed in the theory of hydraulics, by automatic tool designers, pump and compressor engineers, and the nation's leading consultants in this type of work. This mass of technical information will be available after the war to everyone interested.

Less specific, apparently, is the possible application of some phases of supercharged aircraft cabin engineering to the passenger car of the future. High altitude flying has intensified research and development in this field, and a number of aeronautic engineers have sketched schematic layouts for air-conditioned automobiles for this writer on paper napkins at lunchtime. There will be rich technical fare for engineers interested in this idea to improve refrigeration equipment in food and product trucks, and increasing passenger comfort in buses and automobiles.

More specific will be the many applications of advanced manufacturing techniques stimulated by the demands of war production. As production requirements expanded at a rate approaching an explosion, armament orders poured into automobile, truck, and component part factories, as well as into factories of every other American industry. It was this transition from military arsenals to American factories everywhere that brought to arms production the best practice developed by a highly competitive economy, and added something new in redesign of weapons for mass production, in metallurgical improvements, and unheard-of speed of production.

CARS LAST LONGER—Thus production experience of the past was correlated, and the demand for great speed in output focused the attention of production engineers in every corner of industry on every possible improvement in production techniques. This is the background in considering the statement made at the recent SAE meeting by an automobile engineer that the demand for 6,000,000 automobiles in the immediate post-war period will be met readily. But a challenge to continued output at that level was expressed in a study that revealed prolonged ownership of automobiles had proved successful in the present war period. Surveys indicated that the pre-war cars had stood up under the longer-than-usual ownership, and that the pre-war frequency of trade-ins may be reduced in view of this experience. It was pointed out that average age of passenger cars in service today is about eight years.

This enforced prolongation of passenger-car use also has disclosed that such things as obstinate door locks, malfunctioning window regulators, ignition troubles, and failure of steering equipment to maintain alinement—to mention a few faults—will have to be overcome if long-time use of cars becomes established practice. Some engineers believe that frequent trade-ins will again be the rule as soon as the immediate demand for new automobiles had been satisfied, but most agree that this sort of guessing approaches clairvoyancy, a subject not taught in engineering schools or practiced in engineering departments.

Earlier this year when Government officials announced that arms output for 1945 must be larger than the 1944 totals, engineers in the Detroit area were unimpressed by doubters. What has them going on a night-and-day basis is some of the new requirements for weapons not yet publicly announced. The details, in terms of new tools, component parts, and dollars, are astronomical. But no one even hinted that the orders could not be met, and most of them have promised themselves that they will be met ahead of schedule.

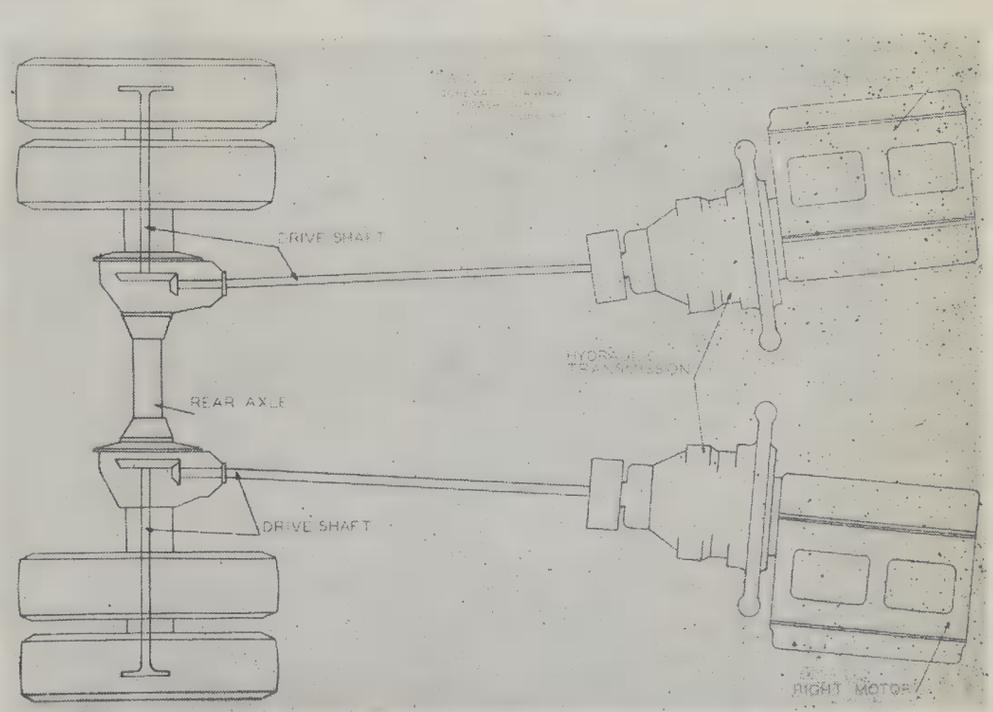
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FUTURE ENGINES

Must Give Greatest Value Regardless of Form

ENGINEERS attending the War Engineering-Annual Meeting of the Society of Automotive Engineers in Detroit were challenged by the organization's former president, Charles F. Kettering, vice president of General Motors Corporation, to "find the best combination of engine and fuel to give the greatest value per total dollar."

Mr. Kettering told his audience that it makes no difference whether the engine is for gasoline or Diesel fuel; whether it is a two-cycle or four-cycle engine; whether it be reciprocating or non-reciprocating. "Engines are made of metals and brains," he said, "and they need as much of the latter as we can get into them."



Courtesy Twin Coach Company

One method of installing twin engines in a bus is shown by this schematic drawing, which indicates the use of hydraulic transmissions. A pre-war development, multiple engines are widely used in many military vehicles. From the success obtained, they appear destined to find wider and more varied application in the post-war period

Metals By Electronics

In Mines and Mills, Electronics Speeds Production, Increases Safety, Improves Quality. Some of the Applications Described Point the Way Toward Even Greater Diversification of the Uses of Electronics

By VIN ZELUFF
Associate Editor, *Electronics*

SAFETY devices, automatic controls, induction heating units, power-conversion substations, and a host of weighing, sorting, measuring, and automatic inspection devices are among the many forms of electronic equipment being used in mining operations and in metal refining and rolling mills. These tube-operated units have played a major role in producing the vast tonnages of metals needed for mechanized war.

AT THE MINE—Photoelectric relays control the dumping of ore trucks in a Minnesota copper mine. The truck backs onto a ramp. For full safety two photoelectric relays are installed; the truck must intercept both beams. The breaking of the beams by the truck energizes a solenoid air valve, opening a dump pocket. If the truck is not in proper position to intercept both light beams, the pocket remains closed.

In another example a large power shovel in an open-pit mine changes its operating position on an average of once every 45 to 60 minutes. It does not move far, and it moves slowly. The weight of the shovel is 1500 tons or more, supported on four large crawler trucks, one at each corner of the machine.

During normal operations of such a large stripping shovel, the lower frame must be close to level. Otherwise, the rotating motion will be severely handicapped, because it will work against gravity in one direction, and with gravity in the other.

Therefore, all modern, large stripping shovels are now built with four hydraulic leveling jacks—one at each corner directly over the truck. The leveling unit on many shovels is controlled by photoelectric relays. The operator merely presses a button in the cab. A signal light indicates when the operation is completed. Leveling is accomplished to an error of less than a half a degree in a half minute or less.

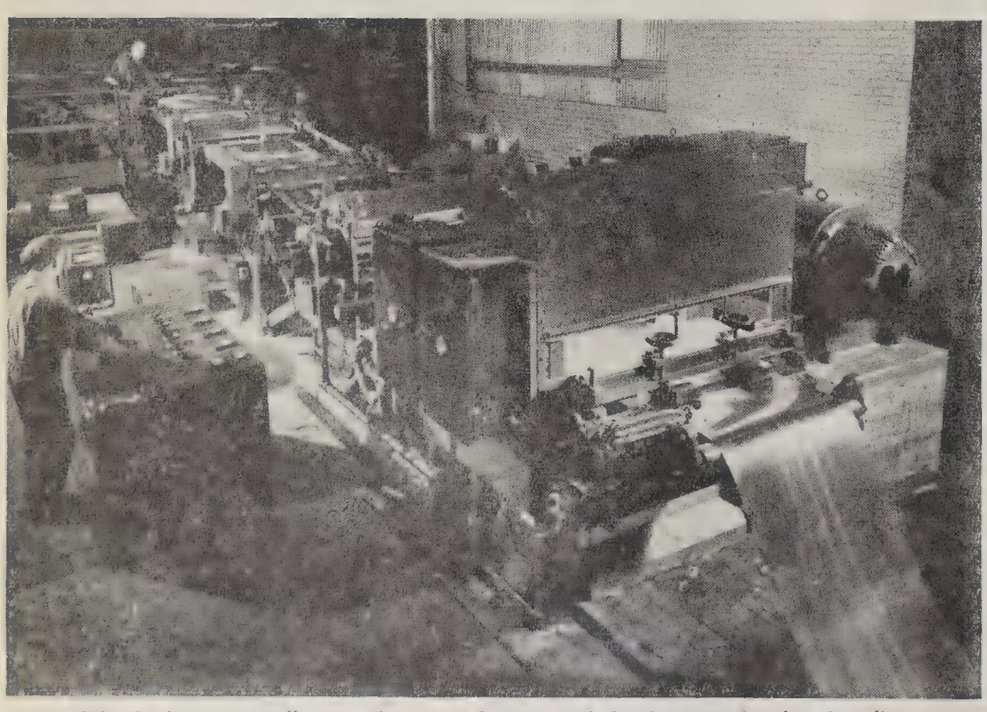
IN THE MILL—In one steel plant, a flying shear is located between the intermediate and finishing stands of a 10-inch hot strip mill. This shear cuts off the relatively cold front end of the bar before it enters the finishing stands. Formerly an operator had to start the shear when the strip was in the proper position, so as to cut off a definite crop length. Now phototube equipment automatically starts the shear. An adjustable time relay is used to determine the time interval between the interruption of the beam of light and the starting of the shear, thus compensating for changes in the strip speed, since the strip speed when it reaches the shear is adjustable from about 400 to 550 feet per minute.

In a Chicago steel mill, the soaking pit crane operator opens the soaking pit cover from his crane cab through the action of photoelectric equipment. When the crane is over the soaking pit from which the operator desires to lift an ingot, he steps on a foot-operated pushbutton which will momentarily illuminate a "light box." Opposite the light box is a phototube unit with amplifier. When the light strikes the phototube the cover opens. As soon as the ingot clears the pit, the operator again steps on the pushbutton to illuminate the light box and the pit cover automatically closes.

A photoelectric unit in another steel strip mill slows down or speeds up one of the sections of the mill to maintain a constant loop in the strip being processed. Normally the loop is of such a length as to block about half of the light-beam system. If the loop shortens, the phototubes get more light and the associated electronic motor control system adjusts the speed of one motor to make the loop longer. Correction is made in the opposite direction when the loop gets too long and blocks all of the light beam. With this ingenious arrangement, two separate motors can operate two different sections of a conveyor or two separate stands of a mill acting on the same continuous sheet of hot or cold steel.

HOLE DETECTOR—Not all photoelectric applications are for regulation purposes. An important steel mill application of another type is one that detects holes in strip steel. This application is particularly desirable on steel which will later be tin-plated for use by the canning industry.

Prior to the use of pin-hole detectors, it was difficult visually to inspect the strip effectively, and food spoilage often resulted. The modern photoelectric pin-hole detector will inspect steel strip at speeds up to 1500 feet per min-



Westinghouse installation (foreground) of pin-hole detector in shearing line

ute and detect 1/64-inch or smaller holes. Some operators have reported consistent detection of holes as tiny as 1/200-inch diameter. The detector operates a marker which places a visible mark on the strip at the location of the hole so that it can be readily located later. In many installations, the detector also operates a classifier that automatically rejects defective sheets after they have gone through the shear which usually immediately follows the pinhole detector.

Before tin-plate is shipped to the can manufacturer, it is gaged for thickness and sorted into piles, each containing a definite number of sheets. Gage is now measured electronically. If the thickness varies beyond the allowable tolerance, a signal from the gage, electronically amplified, actuates a contactor which in turn operates a reject gate to divert the off sheets.

An electronic counter is used to determine the number of sheets going into the prime pile. Sheets intercept a light beam directed on a phototube feeding an amplifier and contactor. Each time the light beam is intercepted by a sheet, the contactor is energized and in turn operates a magnetic counter. After a predetermined number of sheets reach the piler, the conveyor stops automatically.

A side-register control installed in steel mills automatically shifts a steel-strip winding reel back and forth, compensating for lateral variations so as to obtain a coil with smooth ends. A light beam makes a continuous check on the strip's position, and a variation of even a few thousandths of an inch is sufficient to bring about a corrective action. This equipment is installed on many electrolytic tinning lines.

HEAT MEASUREMENT—The General Electric photoelectric pyrometer provides a dependable method of indicating and recording the temperature of a hot bar of steel. Radiant energy from the hot body is directed toward a phototube, causing the tube to pass a current bearing a definite relation to the temperature of the hot body. The current is amplified and passed through an indicating instrument which charts the temperature. High speed of response makes the pyrometer extremely suitable for indicating the temperature of successive pieces passing in process, such as bars or billets passing through a steel mill.

One of the early installations of the photoelectric pyrometer was on a piercing mill where steel billets are made into seamless steel tubes. Three furnaces served the mill, and there was much variation in temperature of billets from the different furnaces. The pyrometer indicated billet temperature, with the good result that both mill operator and furnace man had a measuring stick with which to guide their operations. Spoilage was greatly reduced.

In another steel mill a pyrometer indicates bloom temperature as blooms leave the mill. The instrument is provided with two control points, so connected that signal lamps light in the operator's pulpit if the temperature of the bloom is too high or too low. Thus, if temperature is too high, the operator waits until the temperature-recording instrument shows that the bloom has cooled sufficiently before he sends it on to the billet mill.



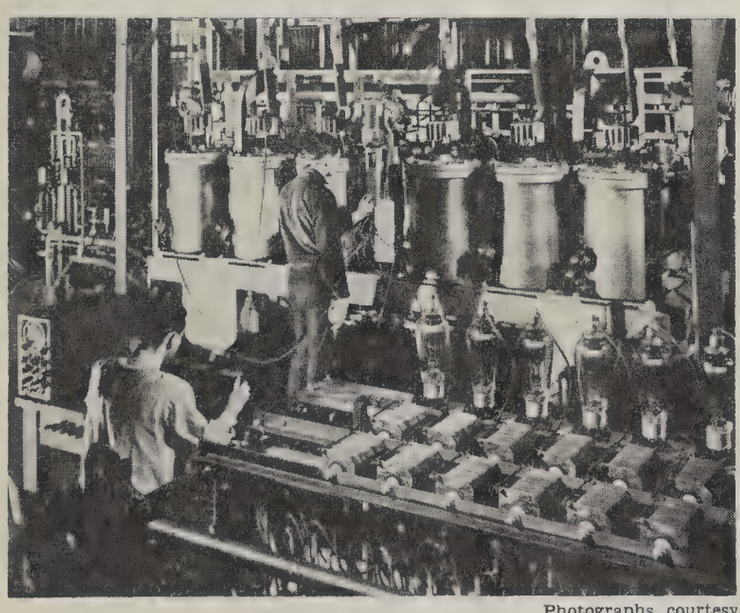
Uniformly wound coils of strip metal are being produced in steel mills by the use of photoelectric controls that scan the edge alinement of the strip before coiling. The protecting cover has been removed from this General Electric unit to show the scanning head

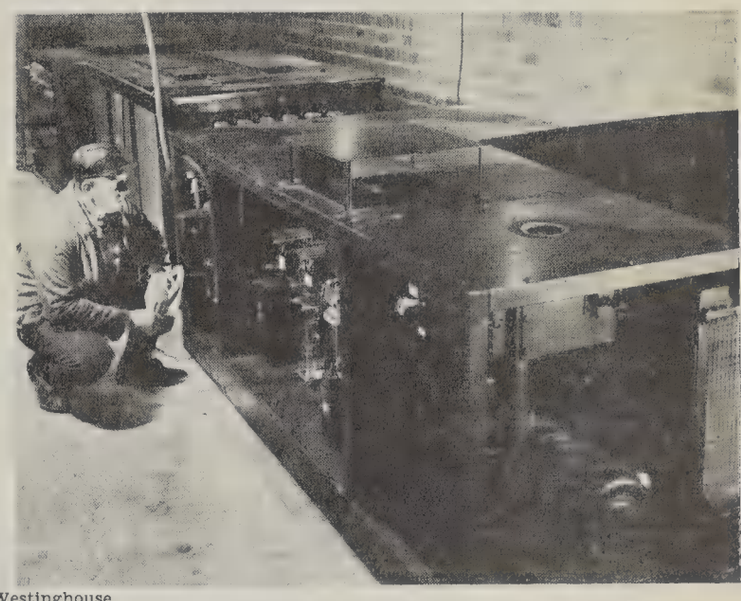
When the pyrometer was installed on a spinning machine for manufacturing cast-iron pipe by a centrifugal-casting process, a better and more uniform product was obtained and the machine's productive capacity was boosted.

After the spinning machine has been started and brought up to speed, hot metal is poured in. The pyrometer then is arranged to indicate temperature inside the pipe. When the pipe cools below a critical temperature, the pyrometer causes the spinning motor to be stopped. Human error is avoided, and the spinning machine runs no longer than is necessary to permit solidification of the metal.

Since its invention, the Bessemer converted has depended upon the human eye for control of temperature and determination of the end point of the blow. Catching the end point exactly is a matter of utmost importance. If a few seconds of overblowing takes place, the iron oxidizes rapidly. If the blow is stopped too soon, excess carbon may make the steel unusable.

The Bessemer flame control, an invention and development of the Jones and Laughlin Steel Corporation, using





Photographs courtesy Westinghouse

Shop-testing a huge ignitron rectifier assembly that is now being used in the electrolytic production of aluminum

D.C. end of a portable ignitron unit, with a capacity of 300 kilowatts, designed especially for use in a coal mine

G-E photoelectric equipment, now watches the flame unflinchingly through a series of carefully selected filters, records the progress of the blow, and makes it possible to halt the process at a preselected end point.

AUTOMATIC TESTS—Instead of laboriously watching through a microscope to measure the rate at which metals flow when heated and stressed, metallurgists have substituted a photoelectric unit for the human eye and can now go about more important work while these tedious metallurgical tests go on automatically.

In the new technique, a thin wire sample of the metal to be tested is enclosed in a glass cylinder. Electric current is sent through the wire to heat it to perhaps 2000 degrees, Fahrenheit, and a weight is attached to one end of the wire to keep it taut as it expands. Also attached to the wire is a glass grid ruled with opaque horizontal lines 1/250 inch wide and the same distance apart. An identical grid, nearly in contact with the first, is rigidly attached to the glass cylinder. At the beginning of the test, the grids are adjusted so the lines on one just fill the spaces on the other, and no light can pass from the lamp on one side of the setup to the phototube on the other side.

As the test wire stretches, it slowly moves one grid, allowing more and more light to reach the phototube. The resulting output of the phototube is amplified and fed to a recorder that inks in the amount of stretch on a moving calibrated paper scale. By this electronic technique it is readily possible to measure a stretch or creep as small as 1/10,000 inch in a metallurgical sample.

RECTIFIERS—The hesitancy of some industrial companies to use ignitron-type mercury arc rectifiers is fast disappearing. Electronics is now being put to work on a really big scale. In the five-year period from 1938 through 1942 the total sales of electronic rectifying equipment in this country was of the order of 120 million dollars.

In one western steel plant alone, these rectifiers, with a capacity of 14,000 kilowatts, are supplying power for driving auxiliary machines in the steel mill. Also, an ignitron rectifier is supplying the power to the main-roll motors in another western steel mill. Direct current is used underground in all mines, and more and more of them are discarding motor-generator sets in favor of more efficient and more reliable electronic rectifiers.

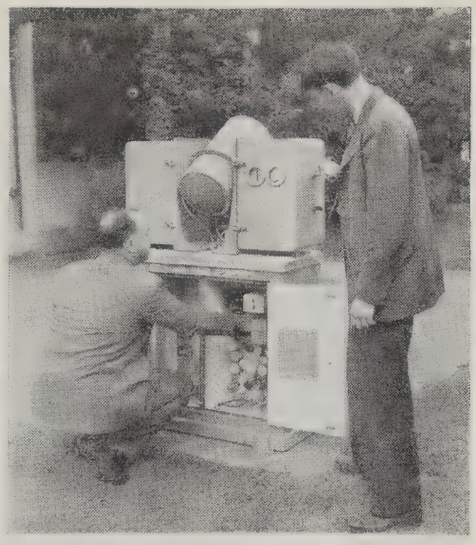
Some of these metal-clad rectifiers require a vacuum chamber eight feet in diameter, and stand seven or eight feet high. Such electronic giants have played a very important role in the recent tremendous expansion of the aluminum and magnesium producing facilities for war use. The tubes can be made with far less critical material than corresponding rotating-type converters, and their used saved an estimated 20,000 tons of steel and 3,750,000 pounds of copper at a time when the metals were extremely critical. They provide the vast quantities of D.C. power needed to produce aluminum from mud and magnesium from sea water.

The close working relation developed between electronics and the metals and alloys industry in wartime shows every sign of continuing after the war, to the mutual benefit of all concerned. Here, as in its many other fields of usefulness, electronics is making it possible to turn out a better product faster and at lower cost, and is thereby rendering a service to industry that cannot economically be discarded on reconversion day.

CLOUD CEILING

Measured by Brilliant Light Plus Photocell

HEIGHTS of clouds from zero to two miles up can be measured accurately and automatically in daylight or darkness with an electronic ceilometer jointly developed by the United States Weather Bureau and General Electric Company. A tiny high-intensity mercury arc lamp mounted at the focus of a searchlight mirror throws a 120-cycle pulsating beam vertically upward. Although the flickering spot thus produced at the cloud ceiling is not visible to the human eye in daylight, it is readily picked up by a phototube and amplifier unit located 1000 feet from the projector and tuned to the same flicker frequency of 120 cycles. A Selsyn motor drive between the various units translates the output meter reading into cloud heights indicated directly on a recording unit.



The new G.E. ceilometer obtains cloud ceiling data valuable to all aviation

FRACTIONATION

Speeded by Electronic Recorder

IN MODERN oil refineries, accurate boiling points of the various vapors to be separated in fractionation must be predetermined in the laboratory.

An electronic instrument for this purpose, made by Brown Instrument Company, consists of a continuous-balance potentiometer pyrometer which is mechanically connected to a conventional recording potentiometer.

A special high-sensitivity fine-wire thermocouple, consisting of six individual couples spaced about one half inch apart, is located in the reflux zone of the fractionating column. The electromotive forces produced by these thermocouples are amplified by the electronic tubes and recorded continuously by pen on a time-temperature strip chart.

The electronic recorder and a special Podbielniak fractionating column make possible rapid and accurate separation of compounds whose boiling points are only one and one half degrees apart, a feat which cannot be accomplished by the older type of apparatus.

The new electronic development considerably reduces distilling time, with increased accuracy, and opens up a new field in the fractional distillations required for producing the new "100-plus" octane gasoline. Richfield Oil Corporation has installed this electronic equipment in its newly expanded refinery near Los Angeles.

STENCIL CONTROL

Provided by Electronic Timer

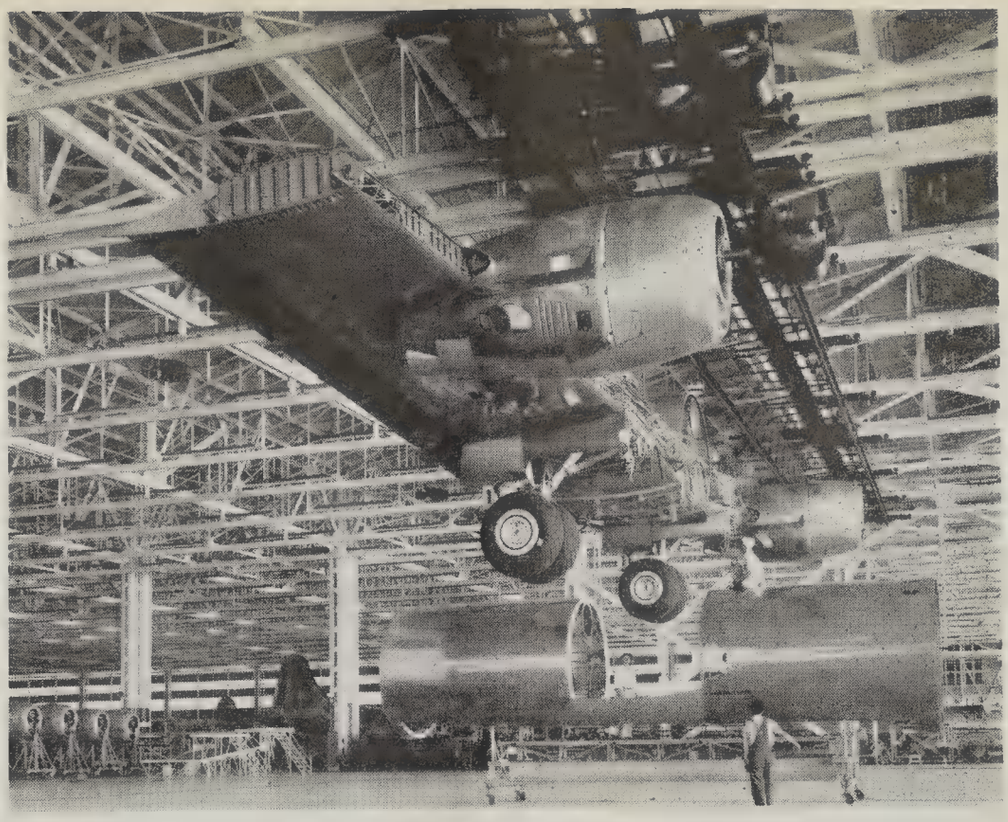
IN A BLANKET factory in Massachusetts, the plant superintendent needed to stencil certain letters on blankets uniformly. In this operation, an electromagnetic mechanism had been used to press the blanket against a paper transfer. Addition of a General Electric electronic timer to the solenoid circuit now allows automatic control of the length of time the blanket is held against the transfer.

FLAW DETECTOR

Prevents Tool Breakage In Machine Shop

IN ONE New England plant, invisible flaws and inclusions in brass bar stock were causing tool breakage losses amounting to over $2000 a week. A complete solution to the problem was achieved by installing an electronic flaw detector to inspect all stock before machining. This device, developed and manufactured by Sperry Products, Inc., detects flaws as short as 1/16 inch, many of which are not even noticeable at the surface. In the first six weeks of electronic inspection, not a single tool was broken, tool life was considerably increased, and over-all production increased 60 percent.

The Sperry flaw detector consists of an electron-tube oscillator that supplies high-frequency alternating current to a detector coil through which the bar stock is passed at rates as high as 80 feet per minute. If a flaw is present, a sensitive electron-tube indicator circuit signals the operator and actuates relays that stop the machine which pulls the bars through the coil. The detector works equally well on both ferrous and non-ferrous metals and on welded or seamless tubing.



Lowering the 17 ton main center wing section of a Superfortress to fit into the fuselage bomb bay section at Boeing's assembly plant in Wichita, Kansas

AVIATION Conducted by ALEXANDER KLEMIN

Metals In The Air

Aviation's Present Achievements Are Based on the Quantity Production of Strong, Lightweight Metals. Of These, Aluminum Is Most Widely Used Because It Combines the Necessary Qualities of Toughness and Lightness with Low Cost. But Steel and Magnesium Are Coming into Wide Use

NOT THE least of the wonders of the modern airplane lies in the airframe or structure. Other branches of industry call for strong, reliable metals, readily fabricated, but the airplane is unique because it demands, in addition to all other qualities, the supreme quality of lightness. If the airframe of the Superfortress were built of mild steel with the same disregard for weight that is shown in the construction of a bridge, it could only carry a fraction of the bomb-load that is now being showered so generously on Japan.

Wood was the first airplane material, but it has largely been replaced by metal. Of recent years, there have been many attempts to return to wood in airplane construction, particularly with the aid of plastics-bonded plywood. The DeHaviland Mosquito, probably the fastest bomber in the world, has a structure almost entirely of wood, and it has been successful in its task of bombing Berlin. Airplane fuselages built of a plastics incorporating Fiberglas have shown remarkable strength in tests at Wright Field. But World War II is drawing to its final phase with metal aircraft holding the predominant position, and plastics still mainly used for non-structural elements.

ALUMINUM IN FLIGHT — The material most important in airframe construction is aluminum, and its application in American aviation began quite early. In 1923, Charles Ward Hall, a consulting civil engineer of note, converted a Navy twin-float seaplane to metal construction, and reduced its frame weight from 358.25 pounds to 164.5, a saving of almost 54 percent. This was such striking evidence of the possibilities of aluminum that, with the financial support of the Aluminum Company of America, there was formed the Hall-Aluminum Company with ample resources for a program of research in aluminum airplane construction.

But no amount of research, no energy in sales engineering, would have given aluminum its splendid position were it not for certain inherent qualities. Aluminum, particularly in its pure state, has excellent resistance to corrosion. It is available in many shapes and forms, and it is easy to fabricate. Moreover, it is very easy to give this bright metal a pleasing finish, and where painting is necessary, the number of filling coats is small compared with that required in steel or wood construction.

But its most important characteristic from an aviation point of view is its low weight compared with that of a steel component of equal strength. The specific gravity of steel is 7.8, and the tensile strength of mild steel as used in general construction is around 50,000 pounds per square inch. On the other hand, the specific gravity of 24 S-T aluminum alloy is only 2.77, and its tensile strength is 68,000 pounds per square inch. So aluminum is only one third as heavy as mild steel, and some 36 percent stronger.

Of course, there are much stronger steels. Some run to strengths of approximately 200,000 pounds per square

inch. There are, however, wonderful newer aluminum alloys in the offing to maintain superiority for the lighter metal. Moreover, in the airframe, and particularly in its cover, a light and relatively bulky material has the local strength against buckling which very thin steel cannot readily attain.

FABRICATING ALUMINUM — Aluminum enters into the airframe in many forms. It is used in sheets, tubing, angles, channels, Z-sections, U-sections, and so on, with sheet or strip form as the most popular. A widely used form is Alclad, an aluminum alloy coated with pure aluminum as a protection against corrosion.

There are many alloys and many methods of heat treatment. The fabrication of aluminum has led to the development of a special technique making use of the hydro-press, the drop-hammer, and the stretch press. All the alloys can be easily formed in any desirable shape, if the material is in the soft (S.O) condition, but there are penalties attached to this simple solution. The high-strength alloys require subsequent heat treatment followed by a rapid cold-water quench. This sometimes causes warping, entailing a consequent costly and time-consuming straightening process.

Aluminum is employed in all parts of the airplane. It is most prominent in wings, fuselage, tail surfaces, and ailerons. An outstanding example is the fuselage of the Boeing B-29, or Superfortress. To speed production, the huge fuselage is built in five sections. The main elements of the structure are the circumferentials or bulkheads or rings, as they are variously called, made of stamped, pierced, and channelled sheets. Through cuts or recesses in these bulkheads pass long channels or stringers. The circumferentials cannot all be of the same size since they must conform to the streamlined form of the fuselage.

After the skeleton structure has been riveted together the fuselage is ready for its outer skin. It is an impressive fact that our constructors have found a way not only of building splendid superbombers, but of building them accurately in quantity and at widely separated plants.

A consideration of one of the steps in assembling the Superfortress affords a clear insight into the accuracy and boldness now employed in metal aircraft construction. Complete with the huge dual wheels of the main landing gear and two of the four 2200 horsepower engines, the 17-ton main center wing section of the Superfortress is lowered to join the fuselage bomb-bay section. Because the two units are manufactured for a perfect fit, it is necessary to jack up the center of the bomb-bay section to allow a quarter of an inch tolerance "spread" as the center section and the fuselage nestle together. Removal of the jacks takes up the quarter-inch slack, and a joint follows in which the pre-bored bolt holes are in perfect alinement.

Another example of aluminum construction is found in the vertical fin of the B-24 Liberator as constructed by Consolidated Vultee. The ribs of the fin have holes stamped out and sides flanged in one operation on the hydraulic press. Rivet holes are later drilled by hand. This indicates that whatever tools and processes may have been developed in aluminum construction, careful hand effort is still an indispensable part of the task.

Aluminum has played a big part in the development of mass-manufactured airplanes. But its story is not finished. New alloys still on the secret list are emerging with tensile strengths greater even than any of the aluminum combinations in general use today.

STEEL IN AIRPLANES — In the use of strip steel in aircraft construction, we have lagged far behind the British. In World War I, tentative orders by aircraft manufacturers for steel called for hundreds of pounds instead of hundreds of tons. The manufacturers consequently decided that steel in aircraft was not worthy of serious attention.

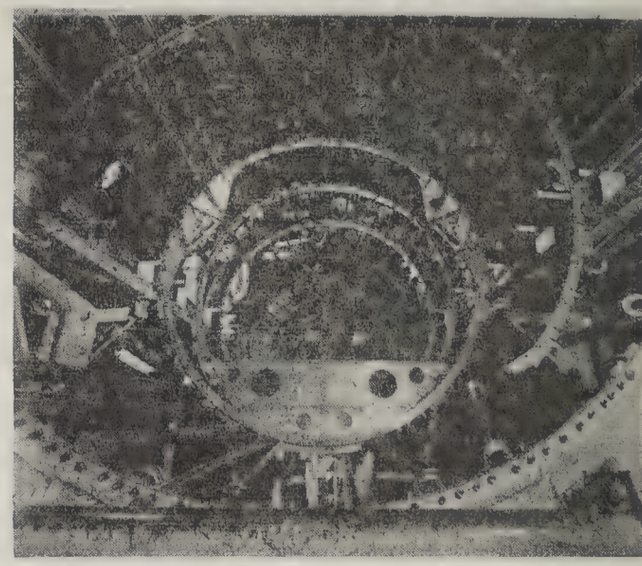
In England, considerably more attention was given to the production of special steel strip and the like. In the United States, even to this day, comparatively little has been done in using strip steel except in the form of stainless steel.

On the other hand, a great deal of steel tubing has been employed, mainly chrome-molybdenum, in engine mounts and in landing gear struts. In the engine mount, the steel tubing probably gives greater concentrated strength and more resistance to the fatigue that follows on engine vibration; and since landing gear struts are exposed, there is advantage in using steel tubing with its smaller cross-section. The fuselage is another place where steel tubing is used. It is generally conceded that Anthony Fokker, the Dutch designer, originated the use of the welded tube fuselage.

At the time the tubular fuselage was introduced, the strongest argument in its favor was that in case of a crash, wooden members break and splinter whereas steel members usually bend and buckle but do not split, thus giving greater safety to crew and occupants. The argument does not apply when a fuselage is built of aluminum, but a welded steel tubing fuselage is cheaper to build, and easier to repair and maintain, than a monocoque fuselage in aluminum. Hence, for relatively inexpensive private aircraft, steel tubing has always been popular.

Outside of the chrome-molybdenum tubing, the steels which have attracted most attention from aircraft constructors are corrosion-resisting steels, often popularly called "stainless steels." These are generally chrome-nickels or chromium steels. Both groups are characterized by high resistance to corrosion, as by salt water, and high resistance to hot exhaust gases, and both groups can be made to develop enormous strengths, over 200,000 pounds per square inch, coupled, however, with rather poor elongation or ductibility.

Moreover, while the stainless steels are difficult to drill and fabricate in general, they can be electrically spot-welded with great success—removing the bugaboo of riveting. Stainless steels have proved, first of all, very useful in such non-structural parts as exhaust collectors and stacks, and it is difficult

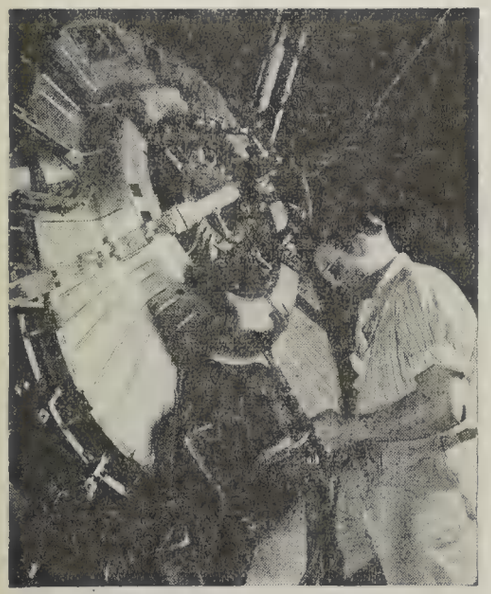


The skeletal structure of a Boeing Superfortress, showing the stringers being riveted to the circumferential rings



This view of the interior structure of a magnesium wing shows how the lightness of the metal permits the use of bulky stringers with great local strength

to see what material could replace them for these purposes. Owing to their corrosion-resisting properties, stainless steels have been employed with success in the building of floats and hulls. Fleetwings has built an amphibian entirely of stainless steel which was popular with private owners. Stainless steel in the structure of the airplane has not achieved great popularity. This is true in spite of the fact that, in addition to Fleetwings' pioneering in this field since 1926, Budd after many years of research, has recently built an excellent all stainless steel cargo airplane. The probable reason is that, while stainless steel has enormous tensile strength, it has less local resistance to buckling because its sections are extremely thin. A stainless steel wing cover is far too thin to be as satisfactory as an aluminum skin. But the last word has not been said. In the larger aircraft that are coming shortly, the enormous



Stainless-steel segments are here being tack-welded for inner rings and muffs on a Consolidated-Vultee plane

loads at the root of the cantilever wing may have to be taken up by deep and solid steel spars.

THE LIGHTER METALS—Magnesium has long been used in aircraft construction in Germany where it is called "Elektron." In the United States it has been employed in many aircraft engine parts, mainly as castings, but it is only within the last few years that it has been utilized as a structural aircraft material and then only in experimental form. Magnesium is being obtained from the sea water by Dow Chemical Company so that it is available to us in great quantities. It has a specific gravity of only 1.8, about two thirds that of aluminum, and a tensile strength up to 50,000 pounds per square inch. Magnesium offers certain difficulties. When it is being machined, protection against fire hazard must be taken. Its fatigue resistance is not perfectly assured and, because it is not as hard as other alloys, its resistance to corrosion is not as high. Hence, in spite of its attractive strength weight ratio, it was viewed with some suspicion by aircraft constructors.

Today, however, machining problems have been largely solved, and chemists at Consolidated Vultee have developed "pickling" or electro-chemical anodizing of magnesium so that it becomes splendidly resistant to corrosion. Dow Chemical, pioneer in production of magnesium, is also doing fine development in building wings and fuselage for a SWJ-2 Navy Trainer. Load tests to destruction have proved completely satisfactory with some saving in weight as compared with the basic aluminum wing.

Because magnesium is so light, it is possible to use bulky sections in the stringers without excessive weight but with local strength. A smooth exterior finish can be obtained with this material because the local stiffness eliminates all skin-wrinkling, and also because fewer rivets are needed. Aircraft construction in magnesium also has great possibilities in saving cost. Because of the greater local stiffness previously mentioned, magnesium will render possible true monocoque construction; that is, a hollow shell cumbered with a minimum of internal parts, spars, stringers, or ribs.

THE IDEAL MATERIALS—F. S. Stewart, in a book on airframe materials, outlines the properties desirable in materials for airframes and within the realm of possibility. His ideal specifications are a fine challenge to metallurgists and inventors. Here they are:

Tensile Strength: 200,000 to 500,000 pounds per square inch.
Specific Gravity: Less than 3.0.
Availability: Unlimited.
Modulus of Elasticity: Above one million pounds per square inch.
Fatigue Resistance: High.
Corrosion Resistance: Excellent.

The day is not far distant, perhaps, when the combined labor and ingenuity of the world's metallurgists and aircraft designers, working in a peace-time atmosphere following a United Nations' victory, will bring forth a material equal to Mr. Stewart's specifications.

PROPELLER ICING

Reduced by Use of Simple Lacquer

THE ACCOMPANYING photograph shows part of an American Airline flagship in flight, with wing edges and propeller dome "icing-up" while the edges of the propeller itself are still free of ice. This is due to a recent development by engineers of Hamilton-Standard Propellers, which increases flight safety.

The safety measure consists in painting or spraying the propeller blades with a chemical lacquer called Icelac, which, black in color, has a consistency something like that of glycerine, and paints or sprays freely to give a shiny, tacky surface.

A satisfactory icing protective surface is maintained for several thousand hours, according to M. G. Beard, Director of Flight Engineering for American Airlines.

The application and maintenance of



The edge stays ice-free

Icelac is simple. Previously, propeller blades were protected by a slinger-ring which distributed an anti-freeze fluid over the propeller blades. The advantages of the new protective method are evident. There is saving in weight, increased simplicity, and a greater assurance of anti-icing protection.

SEAPLANE DOCK

Offers Advantages in Servicing Large Craft

TO FACILITATE handling mail and cargo carried in vast quantities by the Martin Mars and to simplify servicing and maintenance of this giant flying boat,



A tail view of the Mars at its dock

the Navy has constructed a special U-shaped seaplane dock at a west-coast naval air station.

The basic structure consists of standard navy pontoons, over which a three-inch wire-mesh concrete deck is laid after covering the crevices between the pontoons with tar construction paper.

The floating dock provides platforms at either side of the flying boat which may be raised or lowered to a convenient height by changing ballast.

The Mars is berthed in its dock by cables running to fixed electric winches anchored in concrete foundations.

Metals Of The Future

Chemical Industry Provides the Base from Which Spring the Marvels of Metallurgy. Important to Tomorrow's Applications of Metals Is the Developing Knowledge of the Rarer Elements and Their Value in Extending the Usefulness of the More Common Metals in Use Today

METALLURGY advances by adopting and adapting chemical discoveries and processes, and operating them on a huge scale. Indeed, metallurgy can be defined as that division of chemistry and chemical industry concerned with metals and their ores. While that definition serves admirably to characterize the principal fields of metallurgy, and to differentiate them from the remainder of the chemical domain, it leaves a large area of uncertainty. The gigantic iron and steel industry clearly belongs to metallurgy, but proper classification of magnesium production, for example, is not as simple as that and must be dated to have meaning. As recently as a decade ago, metallurgists were still inclined to look down their noses at magnesium and its production in a chemical plant, and few indeed considered it worth serious metallurgical study. Today, that situation is substantially changed and magnesium has grown up among metals. Before our very eyes, martial necessity transferred this expanding section of chemical industry into metallurgy.

Similar transfers have in the past continually enriched metallurgy with territory acquired from chemical industry. And the process continues.

Just as the metallurgy of today is differentiated from that of a century ago by its acquisitions from chemistry, so will the characteristics of tomorrow's metallurgy depend upon what of today's chemistry can be adapted and applied to the problems of metals. We may, indeed, expect to find among the specimens in today's chemical museum the important metals of tomorrow. The methods by which their evolution will most probably be accomplished resemble those recently developed and applied in chemical operations.

MAKING THE MOST OF METALS — The principal preoccupations of present-day chemistry and metallurgy are the development of the techniques necessary to concentrate desired metals from even excessively dilute ores and the economical application of huge concentrations of energy to their recovery. A further consideration, whose significance is being emphasized more and more, is the necessity of using to the utmost the most abundant elements as the base metals of alloys and adding other less common elements to modify their properties in desired directions. This results from rapid depletion of high-grade ores and directs special attention toward the most plentiful elements composing the earth. Aluminum, magnesium, and iron thus become especially important since these three are the only metals presently used for structural purposes among the eight elements constituting 98.6 percent of the earth's crust. Others of these eight, each of which makes up more than 2 percent of the earth, are oxygen, silicon, calcium, sodium, and potassium. The other 84 known elements form together less than 1.4 percent.

The basic pattern of the long-range future of metallurgy thus becomes clear: Alloys of more common elements with relatively minor amounts of other scarcer elements will form the bulk of our future metals.



Before the aluminum solidifies in these molds in the casting building of a Reynolds Metals Company plant, a worker skims the surface to remove the dross

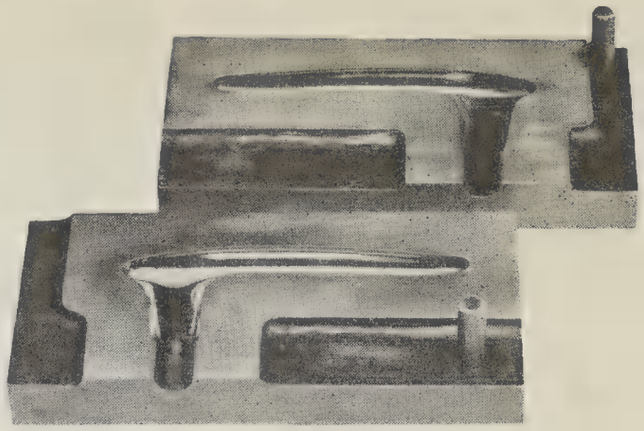
RARE METALS—Less remote in time is the increasing use of many metals, some of them considered excessively rare, to perform specific functions. The stringencies of our war-time economy have brought out many of what may be classed as "chemist's" metals and given them important war-time jobs. Some of these are strange to the metallurgical world but most of them are further developments of less important applications in minor use before. While the total amount of all these newer metals is insignificant in comparison with iron or the other common metals, yet the services they perform are quite disproportionate to their amounts. The number of these metals, too, is relatively large.

The metal indium, for example, has proved to be extremely valuable in bearings of aviation engines where its resistance to wear and corrosion as well as its low frictional resistance makes it particularly valuable as a surface layer. Furthermore, thin plates of indium on silver reduce the latter metal's tendency to tarnish and preserve its high reflectance characteristics. Minimum amounts of indium added to soft solders made of lead and silver impart better flow properties

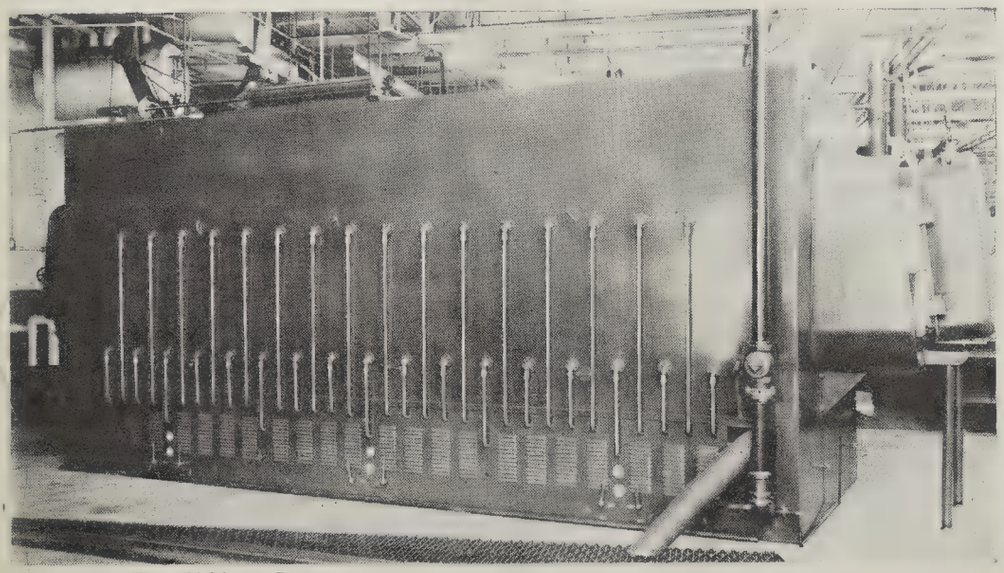
to the alloy and otherwise improve it.

Lead-silver alloys, containing only small amounts of the more valuable metal, are proving as good as or better than the accustomed lead-tin alloys as soft solders. While their present use is necessitated by a war-time shortage of tin, they may well survive competition with tin solders when these are again available.

Beryllium possesses properties of high value in alloys, particularly with copper. Soft malleable copper, to which 2 percent or so of beryllium is added, remains non-sparking and otherwise retains copper's properties



In certain types of molding, and with most plastics, beryllium-copper makes possible molds having extremely smooth surfaces and from which the molded parts emerge with a good finish



Courtesy The Lithium Company

In this heat-treating furnace, lithium is vaporized in amounts sufficient to absorb all oxygen and water vapor in the air or on the steel being treated, thus providing a protective atmosphere which is completely neutral and therefore harmless to steel

but in cast form has a hardness of about 400 Brinnell. That places the alloy in the class of hardness of cast steel and permits it to be used for molds for plastics, for example. The ability to cast molds for plastics, instead of cutting and machining them laboriously from tool steel, materially cheapens this expensive part of the molding business. Copper-beryllium alloys also possess high elasticity and can be fabricated into springs which are both non-magnetic and resistant to atmospheric corrosion. Furthermore, beryllium affects copper's electrical conductivity only slightly as used.

Beryllium also imparts hardness to other metals even when added in small percentages. Aluminum and nickel are susceptible to beryllium additions and become hard and wear-resistant thereby.

Lithium is used as an alloying element for imparting stiffness to aluminum, in high conductivity copper, welding light metals, and for a number of other uses.

Tantalum possesses extraordinary resistance to corrosion, particularly by hydrochloric acid. For this reason it has found important usefulness in the construction of plants for the manufacture of this acid. The fact that it is a metal possessing high heat conductivity, in contrast to previously used stoneware, permits the tantalum plant to be much smaller than accustomed installations and to attain high efficiencies through effective cooling of the reaction zone.

This corrosion resistance of tantalum also makes it valuable in orthopedic surgery. Splints of the metal attached directly to the fractured bones are not affected by body fluids and hence need not be removed after healing is complete. Tantalum, in addition, has the property of electrical rectification when used as one electrode in an electrolytic cell.

Columbium, a metal associated with tantalum and resembling it in many ways, is useful in high-temperature alloys as well as in electrolytic rectifiers. The need for high temperatures in internal-combustion turbines and other machines makes this metal important.

These metals are still rather definitely in the chemical category, but show important promise of development into metallurgical metals. Their special properties give them unusual value in modifying and amplifying supplies of more common elements for metallurgical purposes. They are typical of a larger number finding new usefulness in the rapid development of special metals to meet urgent war needs.

THE LIGHT METALS—Pure electrolytic manganese is similarly a chemical metal which has recently become vitally necessary for alloying with magnesium and aluminum. Manganese is by no means new to metallurgy and in the form of ferro-manganese is a valuable refining agent for steel and a toughener for alloys. The development of aluminum and magnesium on a highly extended scale has greatly emphasized their alloys, among which those with manganese are particularly important. The iron content of ferro-manganese prevents its use with these metals because the iron, which can be neglected in steel manufacture, is highly objectionable in aluminum and magnesium.

Thus necessity has fostered the development of electrolytic manganese on a substantial scale to help in the applications of light metal alloys. This fact has had further significance because the electrolytic operation uses a solution of manganese as its raw ma-



The heavy machinery operations in connection with magnesium production, according to The Dow Chemical Company, use equipment which is essentially standard, the variables being in procedures rather than in machine design. Magnesium tubing can be extruded on equipment used for producing brass tubing; magnesium sheet is being rolled on mills designed for copper and brass and, if necessary, could be produced on steel strip mills with few complications

terial and this can be readily prepared from relatively low grade ore.

Flotation, one of the most significant processes of modern beneficiation, intimately binds chemical industry and metallurgy together. The original process, depending upon the selective ability of foam to float out particles of one kind alone from a mixture, was developed for the improvement of low-grade ores otherwise unprofitable to work. It uses a variety of flotation and foaming agents to accomplish its selections and these are produced by the chemical industry especially for the purpose. Thus metallurgy depends upon chemistry in this field.

But chemical industry also uses flotation in its own operations. Removal of sulfur of colloidal dimensions from the setting baths of the viscose rayon process can be successfully accomplished by flotation, an important fact, since more usual methods are ineffective. A special application of a similar technique is the removal of metallic particles from the emulsions used as cutting oils in machining operations. In a way much more like the customary metallurgical operation, chemical industry employs the flotation principles and process to concentrate certain of its raw materials (phosphate rock, for example) and to remove impurities from certain of its solutions undergoing processing.

MAGNETIC SEPARATION — Modern developments of electromagnetic and electrostatic separations have had important implications in the chemical as well as the metallurgical fields. The separation of minerals which come as mixtures from other separation processes (tabling, flotation, and so on) can sometimes be accomplished by taking advantage of slight differences in either magnetic or electrostatic susceptibilities. It is not necessary, for example, that either of the materials separated be what is ordinarily considered magnetic. A slight difference in susceptibility to charge or magnetism is often sufficient to deflect particles of two kinds into slightly different paths and hence effect their separation.

Clearly a large part of metallurgy is indistinguishable from chemistry and one must look closely to find a basis for differentiating them. Most often the principal distinctions in the area of overlapping lie in the point of view of the one conducting an operation rather than in any characteristic of the operation itself. Continual borrowing and adaptation of the processes primarily designed for one purpose fit them for wider usefulness in the other field.

FUEL TABLETS

Ignite Readily, Give Hot Flame

FIELD rations of the United States soldiers will be heated (if at all) by tablets of metaldehyde, a polymer of acetaldehyde, according to a recent announcement by the Quartermaster Corps. Acetaldehyde, the raw material for these fuel tablets, is not on the critical list as are alcohol, formaldehyde, and other raw materials used in making competitive fuels. Army tablets of metaldehyde are one inch in diameter and one quarter inch thick. In that form the material does not absorb moisture nor does it evaporate. It also possesses high heating value and ignites readily to give a practically invisible blue flame.

BUTADIENE TACKINESS

Increased by New Phenol Materials

ONE OF the drawbacks of synthetic rubber, and especially of the oil-resistant butadiene type used in oil hose, gasoline hose, and other products exposed to oil or gasoline, has been a lack of stickiness or tack of the unvulcanized material. As a result, it has been difficult and expensive to unite parts or plies of synthetic rubber products because they would not stick together during preparation for vulcanization.

It is pointed out by The B. F. Goodrich Company, that, while softeners of synthetic rubber had been previously used in compounding the material, they did not provide tack, and that various tackifying solutions had later to be applied to the surface of the composition. Even this treatment did not give satisfactory tack to some compounds.

In a new Goodrich development, materials of the alkyl phenol class are incorporated into the compound by conventional factory methods either with the rubber as a solid or in dispersion. Use of the materials reduces the difficulties in handling synthetic rubber in manufacturing processes, such as calendering, extruding, or plying-up of successive layers of rubber or rubberized fabric.

BROAD FARM RESEARCH

Urged by Director Of Experiment Station

SCIENTIFIC research will, in the long run, lead to the most direct and reliable solution of farm problems, even though at first there may seem to be little immediate economic gain, according to Dr. A. J. Heinicke, Director of the New York State Experiment Station.

"The knowledge gradually developed by experiment station workers during many years of investigation concerning various phases of production, handling, and utilization of crops," he said, "has been an important factor in enabling a relatively small proportion of the total population engaged in agriculture to provide the large quantities of food required by our military forces and by civilian workers in this country and in many other parts of the world.

"We have had an abundant harvest of practical fruits of agricultural research, and it is fitting that we make the best use possible of all available fruits in this time of emergency even if some of them are still somewhat inmature or imperfectly developed. However, the tree of knowledge upon which we depend for these fruits may fail to produce year after year unless the roots have nourishment and room for spreading. Advantage should be taken of every opportunity to explore new and promising ideas, even if they do not show immediate practical value."

CLOTH TAPE

Treated Against Fungus For Tropical Shipments

A FUNGICIDE treatment is now used in manufacturing Mystik Self-Stik Cloth Tape, making possible the protection of shipments and products against fungus growths, which have proved ruinous to many war materials, particularly those shipped to the South Pacific area. Such precision equipment as radio, radar, and aircraft instruments as well as aircraft fuselages are among the many items that must be protected against fungus attack.

The fungicide is applied to all components of the tape: the cloth, the adhesive, and the backing which impregnates the tape against water, moisture, salt spray, gases, and other damaging elements. The tape is used as a seal in packing and as a protective covering when applied directly to the product itself.

WEED KILLER

Offers Boon to Grass Lawns

NEW control of weeds is promised by a chemical which can be sprayed on a grass plot without injury to the grass itself. Experiments by the Bureau of Plant Industry of the United States Department of Agriculture show that 2, 4-dichlorophenoxyacetic acid (2-4-D for short) in a concentration of five parts in 100,000 of water is effective in killing broad-leaf weeds but harmless to grass.

PLATING ALUMINUM

Accomplished by Means of Surface Treatment

A NEW process for pre-treating aluminum gives it a surface upon which copper or silver can be electroplated. After the usual cleaning, the aluminum is dipped in a solution of a patented mixture of salts which form a plateable alloy on the surface. The treated metal can then be plated with copper or silver in the usual manner. On this first plate other metals may be subsequently plated if desired. Not only can decorative and corrosion resistant platings be made in this way, but the adherent plate can be soldered in the ordinary manner. The process, called "Alumon," is now employed in war work.

Microradiography

A Powerful New Tool And Technique, The Microradiographic Application of X-Rays in Metallurgy, Not To Be Confused with the Familiar Radiography to Which It Is An Auxiliary, Is Giving Aid in the Improvement of Existing Alloys and the Development of Many New Ones

By S. E. MADDIGAN
Research Physicist, Chase Brass and Copper Company

METALLURGISTS, in the examination of metal surfaces with the optical microscope, have long recognized two serious weaknesses in this procedure: (1) The polished surface under observation provides only a plane cut through the details of the metallic structure; this very frequently does not offer adequate evidence of the true shape of the details and in many cases is misleading. (2) The identity of chemical composition of phases, inclusions, or other details under observation can be determined only as a result of long experience and by the use of complicated etching techniques.

As a result, the methods of metallographic microscopy have retained much of the nature of an art rather than an exact science.

The newly developed microradiographic technique, on the other hand, is able to give an indication of the three-dimensional contours of details in the metal structure and is able to indicate the distribution and identity of the chemical components in a precise manner.

The new technique may be considered as an extension of the normal radiographic process. Radiography as commonly practiced reveals the presence on a gross scale of voids, blowholes, and cracks in the metal. Microradiography, on the other hand, discloses the distribution on a microscopic scale of minute voids and even of the alloy constituents. In the latter respect it closely resembles the commonly used optical microscopic methods, but the information obtained is more extensive.

Photomicrographs of polished, etched metal surfaces made in the usual way reveal the metal structure and distribution of phases in the surface only. This information is of extreme value in the development and production of alloys. The microradiograph, however, goes still further in showing the distribution throughout the interior rather than on the surface alone and at the same time provides a definite identification of the chemical elements in the various phases. [A phase is a physically distinct, homogeneous part of an alloy. —*Ed.*]

The additional information provided by this new technique is amply demonstrated by Figure 1. The photomicrograph on the left shows that in the alloy of 80 Cu-10 Sn-10 Pb two phases exist, in addition to the dark particles of segregated lead. The microradiograph on the right shows the actual distribution of the elements copper, tin, and lead. The improvement inherent in the new process over the old method is clearly indicated to the experienced metallurgist.

POTENTIAL USES—The previous discussion at once makes evident the wide potential fields of use for the microradiographic method. In any application of metals where the shape or distribution of phases or segregated particles is of importance, such as, for example, machinability, then it must be recognized that the older methods of investigation using optical microscopy were insufficient, and the microradiographic technique becomes essential. In the development of new alloys involving ternary, quaternary, or even more complex systems, this new technique provides a clear picture of the distribution of the alloying elements and, when used for comparison with photomicrographs, offers extensive information not otherwise directly obtainable. After some experience the method may even be used to identify the composition of unknown microscopic inclusions under conditions where the spectroscopic methods of analysis are of no value.

The microradiographic method depends on the difference in absorption of x rays by the different chemical



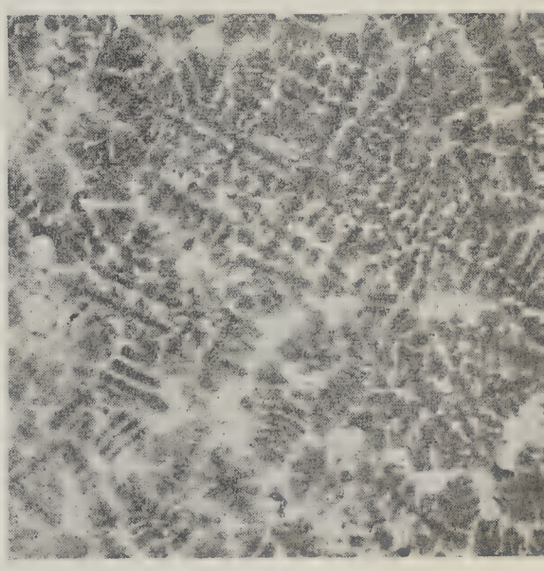


Figure 1: An alloy of 80 percent copper, 10 percent tin and 10 percent lead. Left: Photomicrograph (75X) showing a two-phase system, in addition to black lead particles. Right: Microradiograph (100X) taken with cobalt radiation at 30 kilovolts. Copper-rich regions are dark, while tin-rich regions, also lead particles, are light

elements. Thus, in an alloy structure, constituents having different chemical compositions will absorb different percentages of the incident x-ray beam and can be recognized by the different degrees of blackening in the resultant shadowgraph. For optimum contrast, however, special precautions must be taken. A better understanding of this can be obtained by analogy with photographs taken by visible light.

Both x rays and visible light are manifestations of the same phenomenon of electromagnetic waves. The region of x rays and of visible light both consist of a range of wavelengths; in a beam either of x rays or of visible light a considerable range of such wavelengths will be found. In x rays, however, the wavelengths will be very much shorter than in visible light. A beam of ordinary sunlight or white light consists of a large range of wavelengths, identified by differing colors, which when mixed together, are identified as white light. Suitable apparatus can readily split up this white light into its component colors.

HOW IT WORKS — A simple experiment, using equipment available to the average person, will serve to demonstrate the underlying principles involved in microradiography. This requires some pieces of colored glass and the nearest traffic signal light. Observation of the traffic signal through a piece of deep red glass reveals that, while the operation of the red light can be seen with normal clarity and the yellow light with moderate ease, it is almost impossible to tell whether the green light is on or off. In a similar way a piece of deep blue glass will allow one to watch the operation of the green light but will almost completely obscure the red light. This means that the red glass obtains its color because it transmits red light unimpeded but almost completely absorbs contrasting colors such as green or blue. In like manner, blue glass transmits similar colors such as green but absorbs contrasting colors such as red.

Suppose, now, that an amateur photographer wishes to photograph a scene containing quantities of the color red and the complementary color blue-green. The record obtained on the photographic film will be of rather poor quality since both the red and the blue-green light will affect the photographic film and low contrast will be obtained. However, if a red filter is placed over the camera lens, high contrast is obtainable since the light from the blue-green regions is absorbed and does not reach the photographic film. The light from the red regions, on the other hand, passes through the filter unimpeded to strike the photographic film, and one thus obtains strong black and white contrast. Equal contrast could be obtained by using a blue filter which would absorb the red light but allow the passage of the blue-green light. In this way a strong contrast would again be obtained but the regions of black and white would now be reversed on the negative.

In a similar manner in microradiography, a beam of x rays with wavelengths chosen indiscriminately will probably reveal the alloy constituents with rather poor contrast. High contrast can be obtained in a manner analogous to that used for the photographic case described above. In the case of x rays, however, the control of wavelength is accomplished not by the use of filters but by suitable selection of x-ray target material, or the use of appropriate tube voltage.

The emission from an x-ray tube, as shown in Figure 2, consists of two parts: (1) The "white," or "continuous," background radiation (shown in dotted lines) which covers a considerable range of wavelengths and which shifts to shorter or longer wavelengths depending on the voltage. (2) The "characteristic" radiation (shown in solid lines), superimposed on the

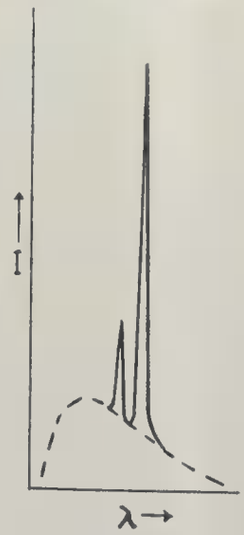


Figure 2: A typical distribution of wavelengths from an x-ray tube. Dotted curve shows the intensity of white radiation, while the solid line that of characteristic radiation

"white" radiation, which consists of discrete wavelengths depending on the material of the x-ray target but not on the voltage.

As will be disclosed, both types of radiation must be considered in obtaining conditions for optimum contrast in the radiograph.

THIN SPECIMENS—The basic procedure for microradiography consists of passing an x-ray beam through a small region of a thin, almost foil-like, specimen and allowing the transmitted beam to impinge upon a special photographic plate placed in close contact with the specimen. The x-ray target material and operating voltage must be carefully selected to give the best contrast. The Eastman Type 548-0 spectrographic plate possesses sufficient resolution to allow the resulting radiograph to be magnified optically by 100 diameters or more. At such magnifications the microscopic distribution of the alloy constituents is clearly revealed in the characteristic shadowgraph.

In order to accomplish the purpose of the technique it is necessary to prepare thin sections of metal of the same order of magnitude as the details or inhomogeneities to be examined. This is necessary for two reasons: (1) The exposure time increases rapidly with the thickness of specimen and, depending upon the constituent elements, thicknesses should be from 0.010 down to 0.001 inch. (2) It is obvious that the overlapping of shadows from a large number of inhomogeneities occurring at different depths in the specimen would cause considerable blurring of detail. Therefore the specimen must be thin enough so that there will not be too much overlapping of shadow details.

From the latter standpoint the necessary specimen *thinness* depends on individual conditions such as size and concentration of inhomogeneities, also on the degree of contrast produced by the difference in absorption between inhomogeneity and adjacent material. For most copper alloys it is desirable to have a specimen thickness of less than 0.005 inch in order to reduce exposure time, but it is seldom necessary to have less than 0.002 inch.

PREPARATION—Such thin specimens are best prepared by a grinding and polishing technique which closely resembles the methods used for the preparation of metallographic specimens. Upon first consideration the preparation of such thin specimens may appear to present great difficulty. However, with a little practice the preparation technique is not unduly arduous and should not deter anyone from using the method.

Specimens should be flat and of essentially uniform gage as first received. Samples of sheet stock satisfy these requirements very well. If castings or large sections are to be studied, specimens should be cut from them so as to satisfy the requirements. This can be accomplished by making parallel cuts on a milling machine or on a cut-off saw provided with a suitable guide or clamping mechanism. As thus cut the specimen will be relatively thick (1/16 to 1/8 inch) and with a surface too rough for direct use and must be subjected to further preparation.

One side is polished on emery papers of varying grades to a final finish at least equal to that obtained on 3/0 French paper using an oil film. The specimen should then be mounted in a Lucite molding with the polished face inward and one unprepared face outward. Then in a lathe the second surface is turned down parallel to the polished face until the sample reaches a gage of about 0.010 inch. From this thickness it should be hand polished until approximately the desired final gage is reached (0.005 inch or less). The surface should then be finished off on French papers to the same degree as the first surface. The entire procedure requires about the same time of preparation as for a good metallographic specimen. The foil-like specimen, after removal from its mounting, is radiographed as previously indicated.

The radiographs may be enlarged by the use of a microscope with transmitted light. This is accomplished with a metallographic microscope by placing the radiographic plate on the stage of the microscope and directing rays

from the light source through the radiograph by means of a 45-degree mirror attached to the stage.

The difference between the absorption of x rays in two materials is in general greater for x rays of longer wavelengths.

The absorption coefficients of metals when plotted against the wavelength of x radiation yield discontinuous curves. The sharp changes or discontinuities occur at different wavelengths for different metals. Also, when used as x-ray emitters, different metals yield, in addition to a general radiation of many wavelengths, one or two wavelengths of high intensity which are characteristic of the particular metal, as shown in Figure 2. By matching these characteristic radiations against the absorption discontinuities for the elements to be examined, it is possible to obtain high differences in absorption between the constituent elements of the alloy without having recourse to the long wavelength, long-exposure time techniques. X-ray tubes with cobalt, copper, and molybdenum targets provide radiations satisfactory for most work with copper alloys.

PARTICLES IDENTIFIED—With several x-ray tube targets available, it is possible to make a chemical identification of inhomogeneities in the alloy by the absorption effects observed; for example, in Figure 3, which shows a copper-zinc-iron alloy, it was possible to identify the small segregated particles as containing iron, since microradiographs with a copper tube showed these particles with strong contrast whereas those with either copper or molybdenum tubes did not show the particles. A consideration of the absorption curves for copper, zinc, and iron showed that such results would be characteristic of iron particles contained in a copper-zinc alloy. In this particular case it was already known from other information such as magnetic tests that the particles shown were iron; however, application of this principle to other cases where the composition of inclusions or segregated particles is not known becomes evident at once.

The author has used the technique for the examination of samples too numerous to be described here. These, however have demonstrated beyond any doubt that the microradiographs give distinctly new and valuable information.

As an example, in studying lead-bearing free machining brasses, photomicrographs usually showed the lead segregated into more or less rounded particles. Microradiographs showed that in many cases the lead was actually distributed in elongated, irregularly shaped stringers. Even the lead particle size indicated by the photomicrographs was frequently quite misleading. Apparently the manifestations seen in the photomicrographs were merely cuts through various parts of the main stringers or their links.

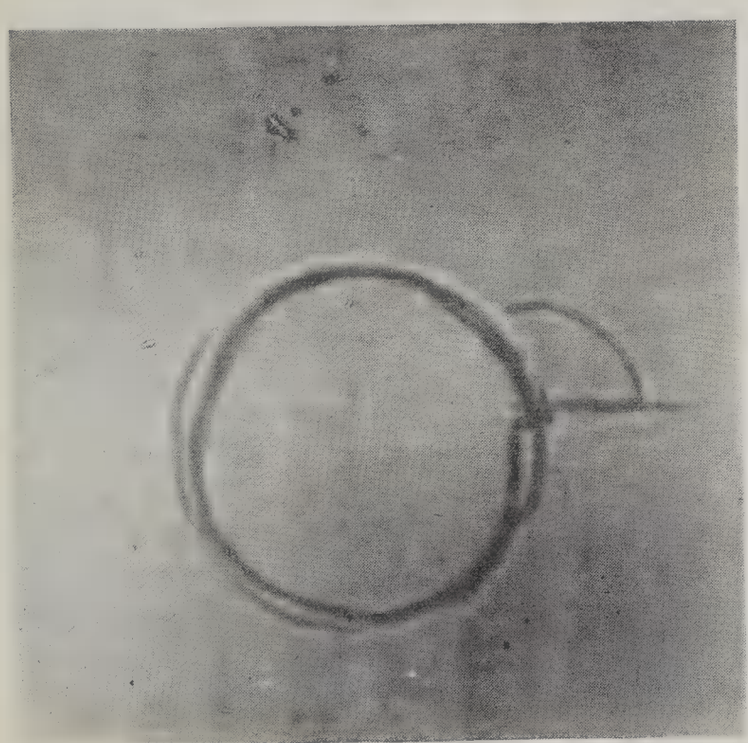
Again, in the examination of a forged copper-zinc-tin alloy, the photomicrographs showed the tin-rich phase as isolated lakes in the alloy structure. The microradiographs, on the other hand, revealed that the tin-rich areas of the photomicrographs were linked together by further tin-rich material along sinuous subsurface paths.

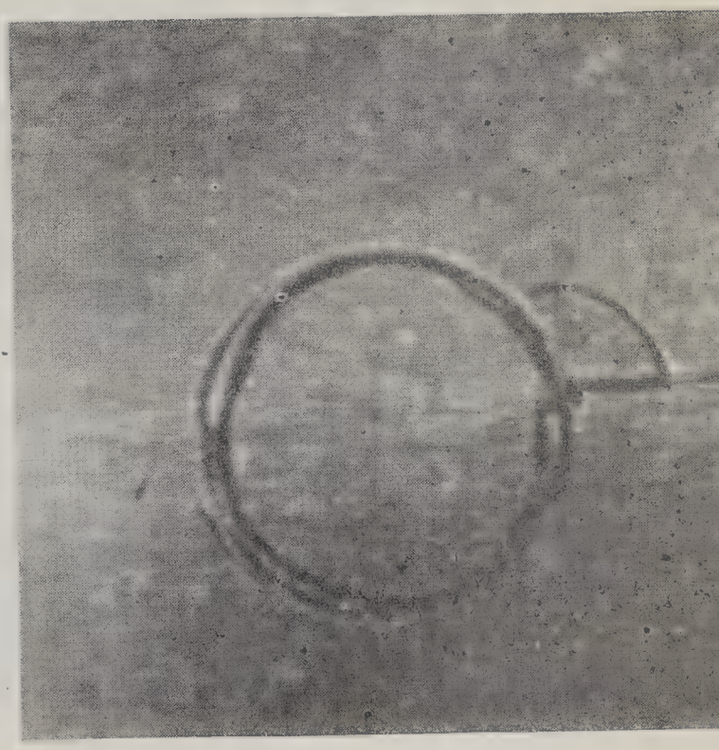
In some cases the new method has been used where normal metallographic methods were very arduous due to etching difficulties. In such cases, since no etching is required for the microradiographic examination, it was possible to obtain evidence of particles which, when examined by optical methods, were either obscured or dissolved away during the etching.

This discussion should give some indication of the possibilities inherent in the new technique. The method is probably not destined to replace the well established procedures of metallographic microscopy. Rather, it should be considered that it is a new tool auxiliary to the optical microscope and that, by proper correlation between the two, much new information will be gained.



Figure 3: Three microradiographs of an alloy of copper, zinc, and iron. Right: Taken (100X) with copper radiation at 30 kilovolts, this one shows segregated iron particles as white against a dark background. Below, left and right: Taken respectively with molybdenum and cobalt radiation at 30 kilovolts, these show practically no trace of the iron particles



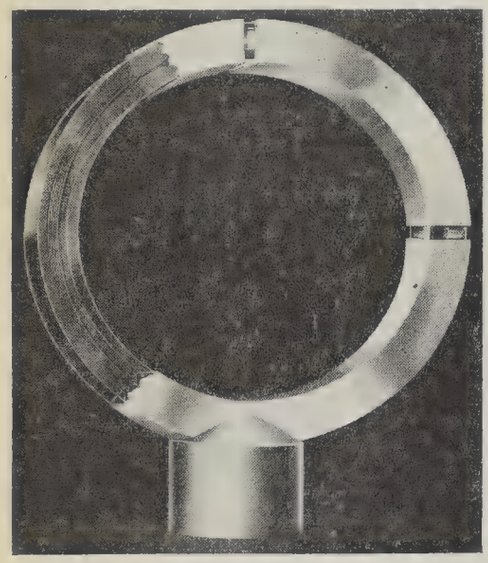


Plastics Plus Metals

Additional Uses for Both Materials are Supplied by Skilful Application of Techniques Now Developing. Metal Coatings for Plastics Take Advantage of Characteristics Not Found in Either Material Alone. Metal Inserts and Assembly Devices Offer Diversity to the Designer

START a discussion on plastics and metals and in a matter of seconds the subject is no longer "plastics and metals" but "plastics versus metals." It is the all too general opinion that an advancement for one of these materials means a set-back for the other.

The long list of products—in large part of a military or essential civilian nature—in which plastics have replaced metals during the last few years



A pure silver shield, electroplated on the plastics housing surrounding the coil of this loop antenna, eliminates the effects of the operator's body and near-by metal objects, at the same time protecting the unit under severe operating conditions

has tended to confirm this opinion. And it has completely overshadowed the fact that these two materials, when skilfully combined to take advantage of the characteristics of each, provide additional outlets for *both* metals and plastics that would not exist for either one alone.

A case in point is the plastics-metal cylinder which constitutes one of the most vital parts of the fire interrupter for a .50-caliber machine gun mounted on certain Curtiss-Wright airplanes. This device prevents the turret gunner from firing into his own plane. The problem was to construct a plastics cylinder, approximately eight inches long and six inches in diameter, whose surface is entirely covered with a layer of silver except for one small area in the shape of the profile of the airplane. When the part is complete and installed, an electric current of about ⅛ ampere at 24 volts, supplied through a fast-acting relay and solenoid, passes through the metal layer. The line of demarcation between the plastics and metal surface must be very sharp to insure an accurate and complete make or break of the electric contact when an exploring point passes over it.

ELECTRICAL USES — Some of the most valuable plastics and metal applications have been in the electrical field. For example, instrument boards on a plane must have a metal backing which serves as a shield. Until recently, large rectangular phenolic laminated sheets, with holes of varying sizes cut out from a large part of the surface, were backed by an aluminum panel. Satisfactory shielding can now be obtained by metal plating the reverse side of the plastics panel.

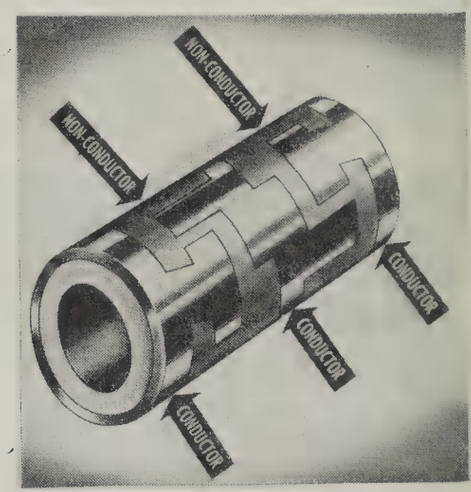
In this same field, metal plating is now being extensively used in the manufacture of intricate commutating surfaces, both flat and cylindrical. This is accomplished by molding or machining grooves in an insulator, then electroplating the desired metal in these grooves until they are filled, and finally machining or grinding the surface. A wide variety of designs is obtained by this method—some having grooves as narrow as 0.005 inch. The need for soldered joints may be eliminated by electroplating connectors between specified conducting surfaces in the same operation.

In the electronics field, the sensitive loop antennas for direction-finding are also shielded by metal plating to eliminate the effects of the operator and nearby metal bodies. This type of shielding is also found advantageous on molded junction boxes, commutator housings, and conduits in aircraft to keep brush arc noises and other interference out of the communication systems.

In the civilian field, the combination of plastics and metal offers many interesting examples. The possibility of partial plating, of design plating, or of covering the plastics entirely by the electrodeposition of metals—deposited singly or in such combinations as gold and silver over nickel or copper, to mention but two combinations—gives new latitude to the designer of household or personal items.

METAL COATING — While these examples illustrate the use of metals on plastics, not all coating operations are carried on in the same manner. The methods of applying a metal surface to plastics can be classified into those which apply the metal without electroplating and those which involve electroplating. The former division includes metal spraying, metal evaporation, cathode sputtering, and chemical reduction to yield a metal film.

In metal spraying, the metal in the form of a wire is atomized in a special oxy-gas or air-gas gun and blown onto the plastics being coated. This method produces a brittle coat with a granular surface which limits its application. A further disadvantage is that each piece must be individually handled by an experienced operator. Another limitation is the necessity for using a low-fusing alloy, such as lead-tin, so that



Electroplated plastics commutators have no gap between insulator and conductor, common in assembled units

the plastics will not be burned or softened. If coatings of other metals are desired, they must be plated on top of the initial coat.

Metal evaporation and cathode sputtering methods are relatively expensive and are used only in special cases where the exact duplication of the contours of the underlying surface is necessary—as for sound recording or

light reflection—or for production of a film of a metal which cannot be applied by other methods. Both methods involve the use of vacuum chambers.

In metal evaporation, the metal is contained in a small crucible or is in the form of a filament. It is subjected to high heat which causes the evaporation of metal atoms that condense on the plastics and all other cool surfaces in the vacuum chamber. In cathode sputtering, the plastics is placed on or near a metal surface which is made the anode. The metal to be deposited is made the cathode. Under the influence of a high voltage—10,000 volts or more—metal ions leave the cathode and deposit on the plastics.

ELECTROPLATING METHODS — When electroplating is used, the surface of the plastics must first be made conductive. This can be accomplished in several ways: By applying waxes and then coating with graphite; by applying lacquers or varnishes containing metal powders; by chemical reaction to yield an electrically conducting compound; or by chemical reduction to produce a metal film or bond coat. The conductive coat is often called the bond coat.

To form the bond coat, application of conducting waxes, lacquers, or varnishes is the oldest of all the procedures, but is gradually being replaced by other methods which require less time or produce more even deposits. The wax method involves coating the object with warm liquid wax, allowing it to cool, and then dusting with graphite or spraying with a graphite suspension. Graphite is employed because it is attracted by the wax. The lacquer or varnish method involves brushing or spraying the plastics with a bronzing mixture which contains a relatively large amount of copper powder. An alternative procedure is to coat the object with a tacky substance and then to rub in a metal powder.

The application of conductive chemical compounds has interesting possibilities, but has not yet proved commercially feasible. One method involves coating the object with shellac, then immersing it in a solution of silver nitrate in alcohol, drying, and exposing it to hydrogen sulfide. This produces a film of silver sulfide which conducts electricity sufficiently well to permit electroplating.

The Metaplast process involves the production of silver films by chemical reduction and is the most widely used method today for coating plastics with metals. The major application for this film is as a conductive coat for electroplating. In this process, the plastic is sensitized with a solution of stannous chloride and then immersed in a silvering mixture composed of freshly mixed ammoniacal silver nitrate and a reducing solution, the main ingredient of which is formaldehyde. Many special variations for plastics have been worked out.

The electroplating process itself follows standard practice with minor variations. For example, since the conductive coat is very thin, a very high current density cannot be used initially on a large piece unless a number of contacts are made for distribution of the current. Furthermore, since the conductive coat is usually porous, highly acid or alkaline plating baths are avoided for the ester type plastics, such as cellulose acetate.



Courtesy Paramount Rubber Company

A plastics fireman's helmet, copper plated by Monroe Auto Equipment Co.

Metal as a coating on plastics is but one of the ways in which these two materials can be used in combination. In addition, there is the use of metal for inserts in all types of molded plastics parts and its use as a decorative inlay.

METAL INLAYS — Among metal embellishments for plastics, metal inlays are important since any design which can be cut from thin stock can be inlaid in plastics by one of several methods which have been developed for the purpose. Inlays may be molded into the plastics pieces or they may be put in after the piece has been molded—the latter procedure having proved to be the more popular.

In one well-known process for inlaying metal, the following steps are involved: A recess following the design of the inlay is made in the plastics material by use of a pantograph or engraving equipment; a thin strip of base metal, about half as thick as the depth of the recess, is then placed in the bottom of the recess; the inlay, which is made slightly convex, is placed above and supported by the thin metal strip, which is harder than the inlay; pressure is applied to the top. When this happens, the base metal causes the inlay to spread out on all sides, permanently locking the inlay in place.

ASSEMBLY DEVICES — There are many types of metal assembly devices that can be used to fasten plastics pieces together or to fasten a plastics piece to other materials. Which device is used in any particular instance depends upon considerations of strength, appearance, and adaptability to mass production. One method—metal inserts molded directly into the material—originated almost with the inception of the plastics industry.

Threads in molded plastics smaller than ¼ inch in diameter are normally designed for screw machine inserts. Above this size, the designer may have his choice, the final decision resting upon the following rules:

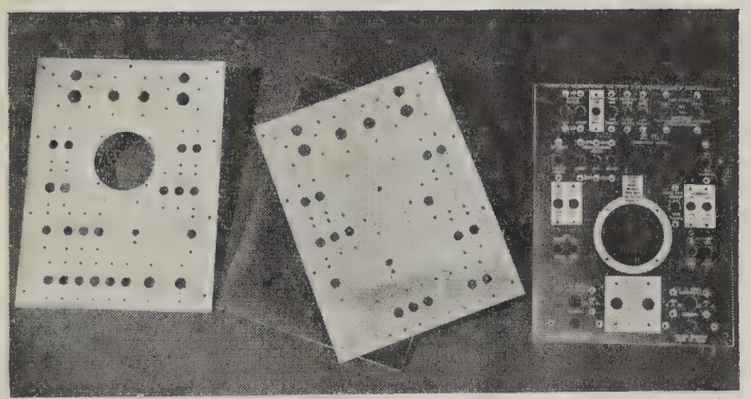
1. Is the assembly to be permanent or must the parts be disassembled at various times? If it is permanent, a molded or tapped hole in the plastic will be satisfactory. If not permanent a metal insert is recommended.

2. Will a continuous substantial stress be placed upon the threaded assembly? If so, a metal insert is recommended. If not, tapped or molded threads may be used.

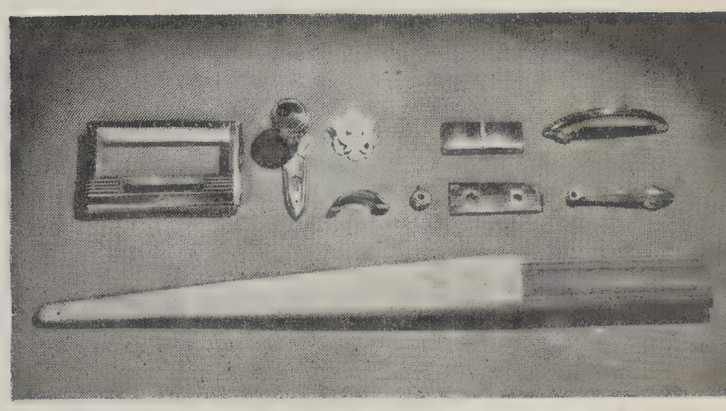
3. Must a close tolerance be specified for the female thread? If so, a metal insert is recommended.

4. If a choice is open to the designer which means of assembly is less expensive?

On the basis of the answer to these questions a designer may use any of a variety of devices. Ordinarily, machine screws are used with inserts, but they can also be turned into holes tapped or molded directly into the plastics material. Metal inserts, instead of being molded directly into the



Instrument panels once made of phenolic laminated sheet backed by aluminum (center) are being replaced by plastics panels that are metal-plated on the reverse side (left). At right is front of new panel, plated by Metaplast Corporation



The successful metal-plated plastics articles shown here include handles, a chime frame, a knob and escutcheon combination, and an antenna mast. The mast (bottom) is made of compreg plated with copper. Base of mast is not plated

plastics, may be pressed into machined holes. The greatest drawback in the use of ordinary molded-in inserts has been the fact that, once molded in the material, they cannot be replaced, since removal would damage the parent material. However, a newly developed replaceable molded-in insert has overcome these difficulties.

When it is not feasible to have molded-in metal inserts, and when holes molded or tapped directly in the plastics lack sufficient holding power, self-tapping or thread-forming screws that make their own threads in the plastic material can be employed. For the same reasons, hardened metallic drive screws which are hammered, pressed, or otherwise forced into a hole cored or drilled into the plastic material, may be used to assemble plastics parts.

When impact-resisting plastics are employed, riveted assemblies often prove acceptable. Speed-nut assembly is not widespread. Constituting an entirely different approach to the problem of attaching plastics to other materials, speed nuts and clips provide the necessary tension after assembly to compensate for any creep in the plastic material. The speed nut is an arched spring-steel fastening device with cam-like prongs which grip studs molded integrally with plastics parts.

Teamwork between plastics and metals has resulted in some interesting developments in a great many fields. With the experience gained during the war period behind them, it is evident that tomorrow's designing engineers will turn more and more to combinations of materials—utilizing each for its most valuable traits.

DYED PLASTICS

Now Make Use of Water Dyes

DYEING clear plastics is by no means new, but use of water dyes is a distinct innovation. In the past dye usually was applied from a solution in acetone diluted with water. This dye, however, requires the most painstaking care because acetone, being a solvent, is likely to attack the surface of the transparent plastic sheeting and cause it to haze and craze.

Danger of harming the surface of a material during the coloring process has been mitigated by the Great American Color Company's introduction of a water dye which deposits color evenly and permanently without destroying the surface luster even though it is applied hot.

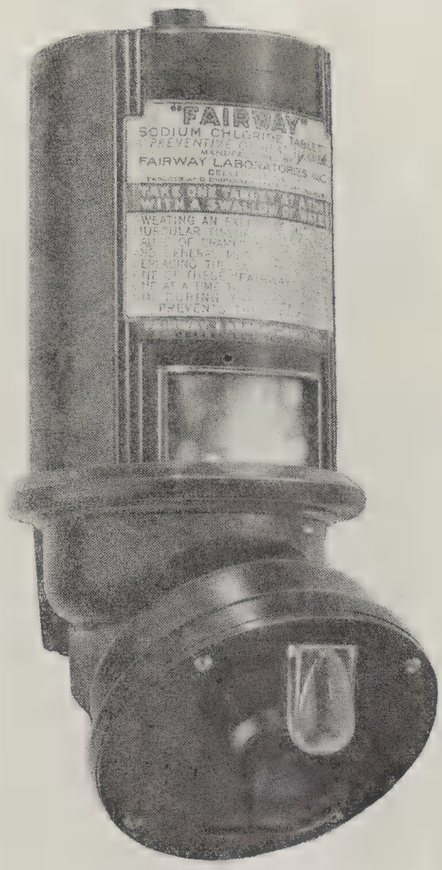
The dye has been worked out in yellow, rubine, red, sky-blue, royal blue, orange, black, amber, scarlet, purple, violet, green, and brown. It comes in a thick concentrate having the consistency of paste and this paste is instantly soluble in water. About 12 ounces of dye mixed with a gallon of water makes a little more than a gallon of the desired coloring. On this basis, one pound of dye will color 16 square feet of plastic material to maximum color strength.

The concentrate is added to cold water, then brought to the proper temperature for the best dyeing results. For acrylics the best temperature is 190 degrees, Fahrenheit; for acetate, under 140 degrees, Fahrenheit. The depth of color is controlled by the length of time the piece is submerged in the bath.

SALT-TABLETS

Dispensed from All-Plastics Unit

FOR workers in industry, salt tablets are sometimes a year-round necessity. To meet the needs of these men and women for an efficient sodium chloride tablet dispenser, the Standard Safety Equipment Company has produced an all-plastics unit which provides protection against moisture and dust, resists salt corrosion, and stands up under hard usage.



It's made entirely of plastics

Eleven parts—two formed of methyl methacrylate and nine of wood-flour filled phenolic—make up this unit. Despite the many joints and junctures, tablets are always dry and in good condition. This is because each piece is carefully designed to make a perfect match with adjoining pieces. In fact, only one rubber gasket is used in the entire unit.

DRINKING CUPS

Molded of Plastics, are Light and Rustless

ONE OF the more interesting civilian items to be made of plastics in the recent past is a collapsible drinking cup. Molded in a two-unit, ten-cavity die of Tenite II by the Plastic Die and Tool Company, these cups have the advantage of being extremely light in weight and impervious to the rust that often renders collapsible metal cups useless after a few encounters with water. These brightly colored Zip-sip cups, as they are called, are marketed by Plastic Molded Products.

PLASTICS SCREEN

Outlasts Metal Wire, Is Strong and Fire-Proof

WHEN our men began fighting in the Pacific area they found that they faced not one enemy but two. Tropical disease—carried mostly by insects—threatened to account for nearly as many casualties as enemy gunfire. It soon became apparent that a screen cloth was needed which would withstand the rigors of tropical climate and yet have strength and durability at least equal to that of metal. The answer to this problem was finally found in plastics insect-screen cloth.

Early in 1942, after testing various monofilaments, the Chicopee Manufacturing Company—well known in the cotton textile trade—began production of millions of square feet of insect-screen cloth extruded from a powder into a monofilament and then woven into a screening from the Saran monofilaments. A unique feature of this company's weaving process is the fact that standard textile equipment common to ordinary cotton textile operations is employed. Because of differences in characteristics of the plastics material as compared to cotton, some adjustments and modifications of the machinery have been necessary. The warp can be prepared on a warp beam or the warp filaments can be brought into the loom directly from the creel (the racks on which the spools of filament used in the warp are placed). This latter method, however, has distinct limitations because of the large amount of space required. In either operation, no sizing of the warp is necessary.

The screen cloth now being used by the Navy, for such applications as tents, is woven in 20 mesh and in a 29-inch width.

The success of this plastics in malaria control is attested by the fact that, by request of the Bureau of Medicine and Surgery of the Navy, it is now installed in the side walls of tents in the Pacific area. Experience to date has shown that this screening will outlast the tent canvas to which it is sewn as well as any type of metallic screening which has been used thus far in the Pacific area.

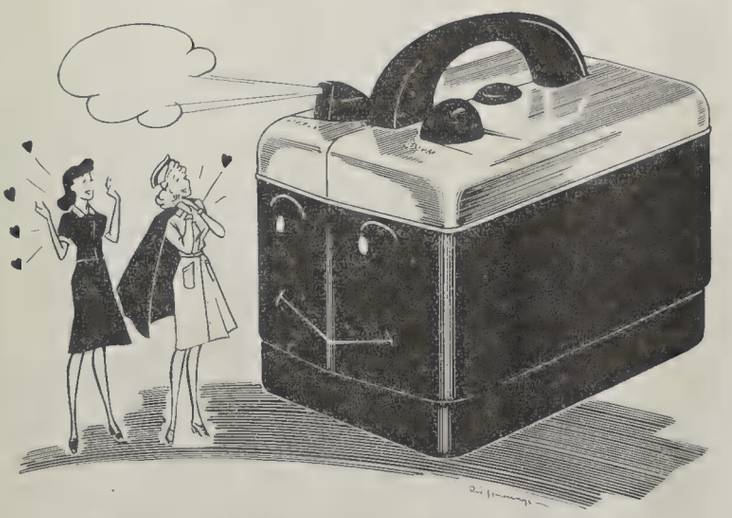
An unforseen virtue relates to the material's flame-proof qualities. The canvas used for the tents is treated with a fire-proofing compound during the process of manufacture. However, when subjected to repeated rains, this compound has a tendency to wash out—and the tent will burn to some extent. However, it has been discovered that if the bottom part of the flap to which the screen cloth is sewn does catch on fire, the flames will be halted when they reach the plastics material.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

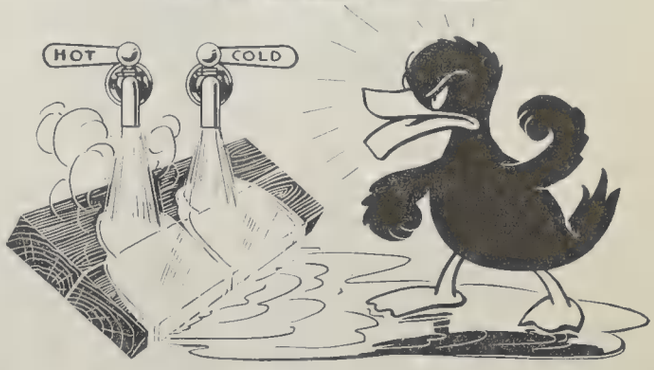
MOLDING COMPOUNDS



WORTH GETTING "STEAMED-UP" ABOUT

Ideal for home and hospital use, the Spartan (Minneapolis) vaporizer is a brand-new development in humidifying equipment. Entirely automatic, this streamlined product holds a full half-gallon of water and gives off steam immediately, even though the water is ice-cold. The unusual design and ingenious mechanical principle of this unit typify the progress being made by American industry in developing new products and improving old ones with Durez phenolic plastics. The unusual versatility of the more than 300 Durez phenolic molding compounds has resulted in their extensive use by manufacturers in practically all fields of industry. Their outstanding properties, such as excellent moldability, diversity of finishes, dielectric strength, and resistance to moisture, heat, acids and alkalies, render them invaluable to the progressive manufacturer with post-victory markets in view.

INDUSTRIAL RESINS



MAKING THE DUCK LOOK LIKE A PIKER

"Like water off a duck's back" doesn't half describe the waterproofness of a Durez 12688 bond. This room-temperature resin adhesive which sets at 75° F. was developed especially for assembly gluing and is completely impervious to water—whether it be ice-cold or boiling-hot. In fact, bonds produced with Durez 12688 are just as waterproof and durable as those in hot-pressed plywood. This remarkable resin opens up many new fields of which laminated lumber, keels, prefabricated housing, and framework parts for aircraft, boats, and buildings are but a few.

OIL SOLUBLE RESINS



HEADACHE CURE FOR A TAP DANCER'S WIFE

Durez phenolic resins lend toughness, mar-proofness, gloss retention, soap resistance, and fast-dry to floor paints . . . make for virtually indestructible floor finishes. The remarkable properties which these Durez phenolic resins impart to paints, varnishes, and enamels, render them invaluable to the manufacturer with a weather-eye on the future.

Although the above constitutes but a brief glance at the vast scope of Durez operations, it nevertheless may suggest an idea to the imaginative mind of a scientist. Durez technicians welcome intelligent ideas which may lead to practical industrial applications of Durez phenolics. As a matter of fact, they have actively participated in the successful development of many such ideas during the past quarter century. Because of the unusual versatility of Durez phenolics, this has been on a scale that is practically universal throughout industry. Durez molding compounds, industrial resins, and oil-soluble resins are all the result of intensive research . . . research which is carried on continuously so as to insure the leadership of Durez phenolics in their respective fields. For further information, write to Durez Plastics & Chemicals, Inc., 524 Walck Road North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

Partners In Production

A Series of Pincers Attacks by Mechanical Engineers and Metallurgists Has Resulted in High-Speed Copper Machining, Better Band Saws, Tougher Cams, Improved Metallizing Methods, and a Number of Other Industrially Important Developments—And the End Is Not Yet in Sight

FOR A GREAT many years, no one tried to machine copper if he could avoid it. The tools would cut all right—tool steel will go through copper like so much cheese. But the trouble was that, unless production speeds were kept low, the copper would tear at the cut surface. Threads intended to be smooth would have jagged edges or even be stripped from the work on which they were being produced. Contours would be pitted and gouged. Work would be spoiled.

Mechanical engineering never stopped trying to lick this problem. Copper resists corrosion so well and is such a good conductor of both heat and electricity that it was needed in machined forms in plenty of assemblies.

Tools were ground to one rake angle and then another, various combinations of machining speeds and feeds were tried, cutting oil research men contributed all they could. Slowly the ability to machine copper was improved. But it was not improved enough to make machined copper parts as useful to industry as they might be.

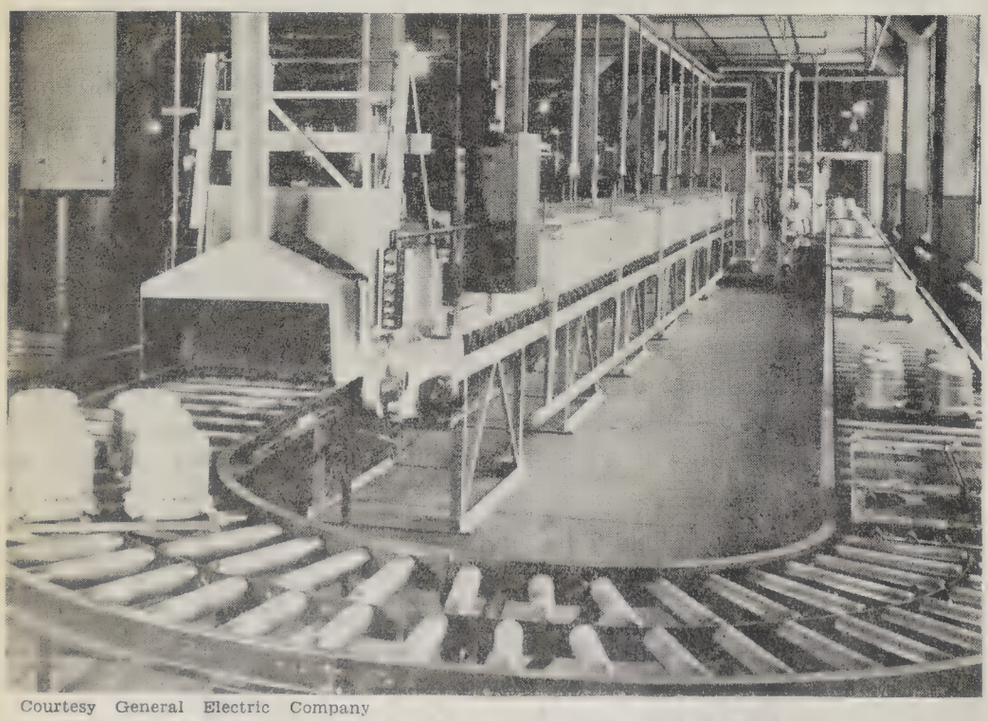
While the mechanical engineers were doing all of this work the metallurgists were busy, too. In fact, copper machining was to be one of those classical examples of a pincers attack upon a production problem—the mechanical engineers operating one jaw of the pincers and the metallurgists the other.

TELLURIUM HELPS — Metallurgy found that alloying tellurium with the copper would improve the machining properties. In one case a production machine which had been running at 924 revolutions per minute while machining copper was stepped up to 1161 revolutions per minute by changing the stock to Revere tellurium-alloyed copper, with no change in the value of the product.

This is more than a 25 percent increase in speed. In peace-time, with the time of a production machine worth from $2 to $5 an hour, such an increase would be worth from $.50 to $1.25 an hour for every machine used on this operation—it could be worth from $1000 to $2500 a year for each machine. And in war-time, this means that four machines will do the work for which five formerly were required, thus freeing the fifth machine and its operator for other badly needed work, or that copper parts desperately needed at the firing lines can arrive there 25 percent faster.

At this point the mechanical engineer stepped in again. The machine was adjusted to increase the feed; the tools were re-ground to produce a finer finish. Soon the machine was turning out 63 pieces in the time formerly needed for 36. And this was not the end. The machine in use was turning as fast as its gears and spindle bearings would permit and was cutting as deep as its motors had the power to force the tools. Only stronger, faster, more powerful machines will find out all that tellurium in the copper can do for this operation.

These more powerful machines are available. If they were not, then new ones would be designed. For this is the nature of the co-operation between mechanical engineer and metallurgist. Each in turn improves his work until he poses a serious problem for the other. The mechanical engineer will bring out a machine to cut tellurium copper faster than the metal can "take it," then the metallurgist will bring out another alloy which is better than the machine, and in a few years the machining of copper will be no problem at all.



Courtesy General Electric Company

This roller-hearth copper brazing furnace set up in a Nash-Kelvinator factory is one more example of mechanical engineering's help to fabricators of metal

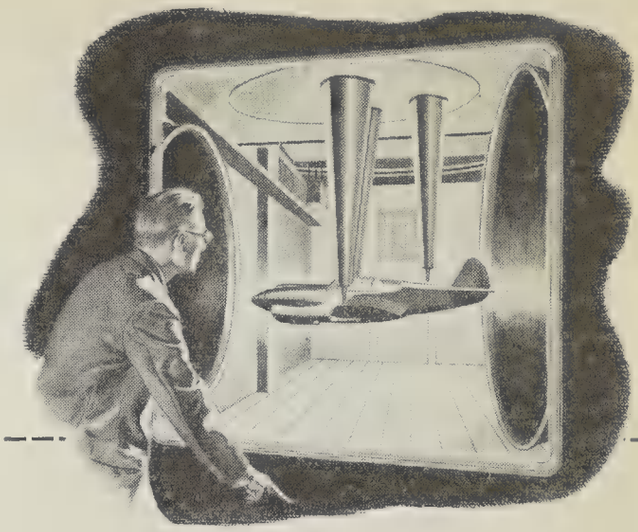
SAWING METALS—Metal-cutting band saws are another example of what happens when metallurgists and mechanical engineers make a pincers attack on a problem.

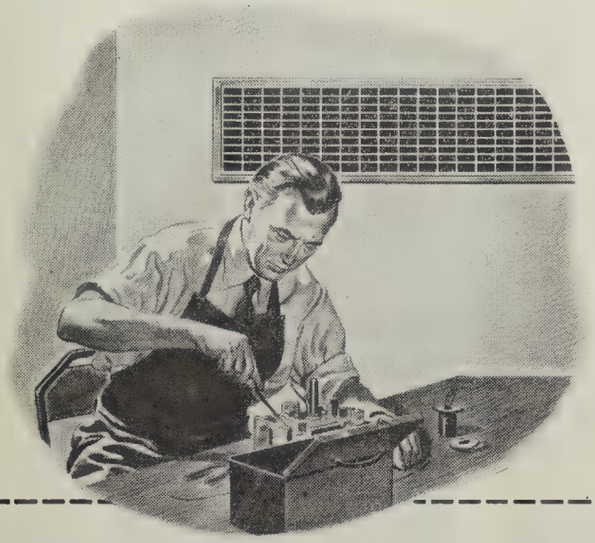
More than 15 years ago the metallurgist brought out a specially tough and strong steel which would permit metal-cutting band saws to be narrow enough for contour cutting. There were limits to the speeds at which cutting could be done. The saw teeth would not clear themselves of chips if traveling at too many feet per minute through the work.

Mechanical engineering designed a Buttress type saw tooth which would clear itself. The saw is of coarser pitch (has fewer teeth per inch of length) than the types formerly in use. With coarser pitch the deep, sharp gullets

In a wind tunnel an AERONAUTICAL ENGINEER uses a 40,000 horsepower electric motor to create a 400-mile-an-hour tornado for testing war planes.

. . . the name on the MOTOR is Westinghouse.



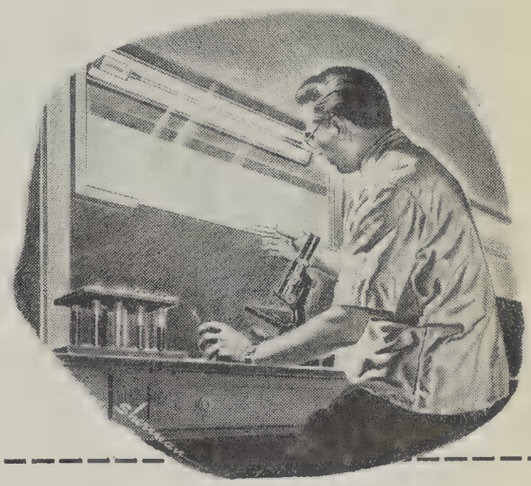


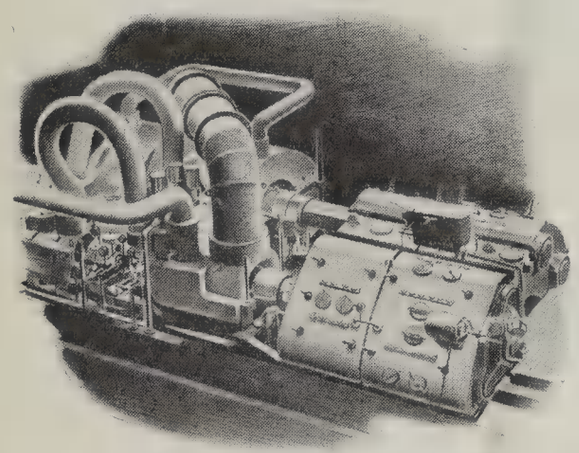
In a factory a WORKER assembles delicate bomb-sight parts in air made dust-free by the Precipitron* electrostatic air cleaner.

. . . the name on the PRECIPITRON is Westinghouse*

In a penicillin plant a SCIENTIST uses a Sterilamp* bactericidal tube to protect this life-saving drug from contamination by air-borne bacteria.

. . . the name on the STERILAMP is Westinghouse.*





On America's largest aircraft carriers the NAVY uses steam turbines which make our carriers the world's fastest.

. . . the name on the TURBINES is Westinghouse.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY – These are some of the ways in which Westinghouse products are serving in the war effort.

TOMORROW – Existing and new products of Westinghouse research and engineering will serve industry and the home.

*TRADEMARK REG. U.S. PAT. OFF.

Tune in: JOHN CHARLES THOMAS—Sunday 2:30 pm, EWT, NBC. TED MALONE—Mon., Tues., Wed. Evening, Blue Network

between the teeth could be eliminated. This made the saw stronger, permitted the saw maker to take more advantage of the strength of the steel which the metallurgist had given him.

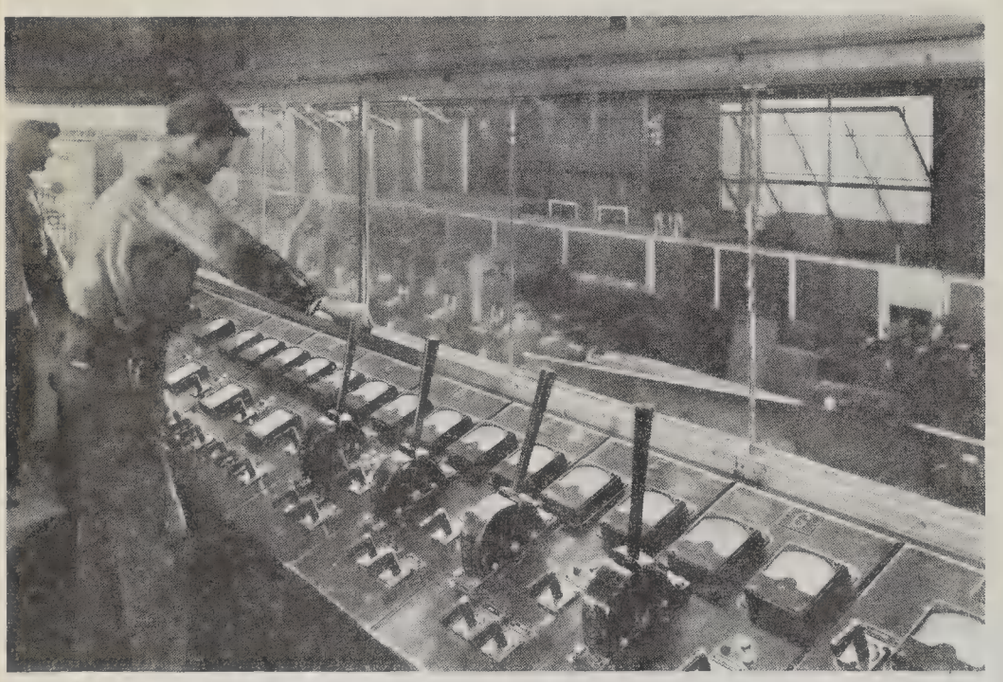
Now the engineers had a saw capable of working at far higher feet per minute, but did not have a machine to pull it. The design and research men solved this problem, too. They had to make their machines more accurate than ever before, put more power at the command of the machine operators, and, beyond anything else, get rid of all vibrations. But they got their machines.

Soon the saws were working at 4000 feet per minute, and 5000, and even 10,000. This opened brand new fields to straight line and to contour band sawing.

No one knows where the limits of this improvement will be. While the mechanical engineer is finding out what can be done with his faster sawing speeds the metallurgist is peering over the shoulder of the saw operator and dreaming up a new kind of saw steel which will make the engineer go running to his drafting board to work out a still more powerful machine.

Welding is another field in which the mechanical engineer and the metallurgist are pinching off problems.

The manufacturer of a mechanical refrigerator wanted to have intricate shaped but rust-free condensing units.



Operating pulpit of a continuous strip mill in a big Bethlehem Steel plant. Metallurgy developed a steel uniform enough to be rolled in this way while mechanical engineering worked out the machinery and the temperature controls

Brass was one material which would not cost much, could readily be stamped or drawn into the desired shapes, and would not rust.

But could the brass parts be fastened together by any such inexpensive method as stitch welding? The refrigerator engineers put this problem up to the metallurgists of a copper and brass company.

Stitch welding depends upon the generation of heat by electrical resistance in the materials to be welded. Ordinary brass would not do; it would generate far too little heat for welding.

The metallurgists solved this by putting a little silicon into the brass. This gave the metal all the electrical resistance needed and did not harm the rust resistance nor create any problems for the brass forming machines. In fact, the brass now can be welded at higher production speeds than the welding machines are prepared to handle. And so once more the metallurgist has put the engineer on his mettle.

METALLURGY IMPROVES CAMS—Control mechanisms for automatic machines are less costly to vary now that the metallurgist has taken his part in the production of them.

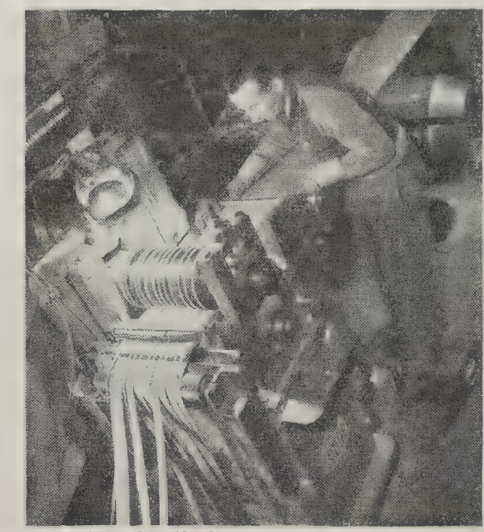
Many automatic controls are actuated by cams. Cams accordingly are found on automatic screw machines, woodworking machines, candy-making machines, brick-making equipment — it would be a rare factory which had none of them. Their odd shaped contours are easy enough to design. The trouble is that these contours often must be accurate enough so they will actuate motions which are figured out to several decimal places. This means expensive machining processes if those contours are to be generated from solid round or square pieces of metal. And with just a little wear many of the cams would be useless. Hence they must be made of hard, tough, abrasion-resisting materials which are difficult to machine.

Metallurgy stepped into this difficult situation with an air-hardening steel which can be cast to shape. Cam shapes from companies like Allegheny Ludlum Steel Corporation are cast so accurately that, even though they have both interior and exterior working surfaces so that several cam followers will move simultaneously along different parts of the same cam, the machine builder or the repair man can finish his cam by removing less than one eighth of stock from any working surface of the casting. Better still, this steel hardens with very little distortion and is extremely resistant to abrasion.

One result of this is to lead the mechanical engineer to design more intricate cam-actuated controls. He knows that the cams can be made cheaply enough so their cost will not make his machine too high in price.

Another result is to permit the production engineer to step up his operating speeds, and to redesign his cams for more exact controlling of special machine indexing and other motions. He knows that he can replace his cams at low enough cost — if indeed these tough cast alloys wear out and need replacing — so he dares to work to unusual accuracies and to place heavy loads on these mechanisms.

When the mechanical engineer has gone far enough in these directions he will be demanding still tougher and stronger cast cam shapes. But then, with metallurgy developing as it is right now, he will be getting them



Courtesy Westinghouse

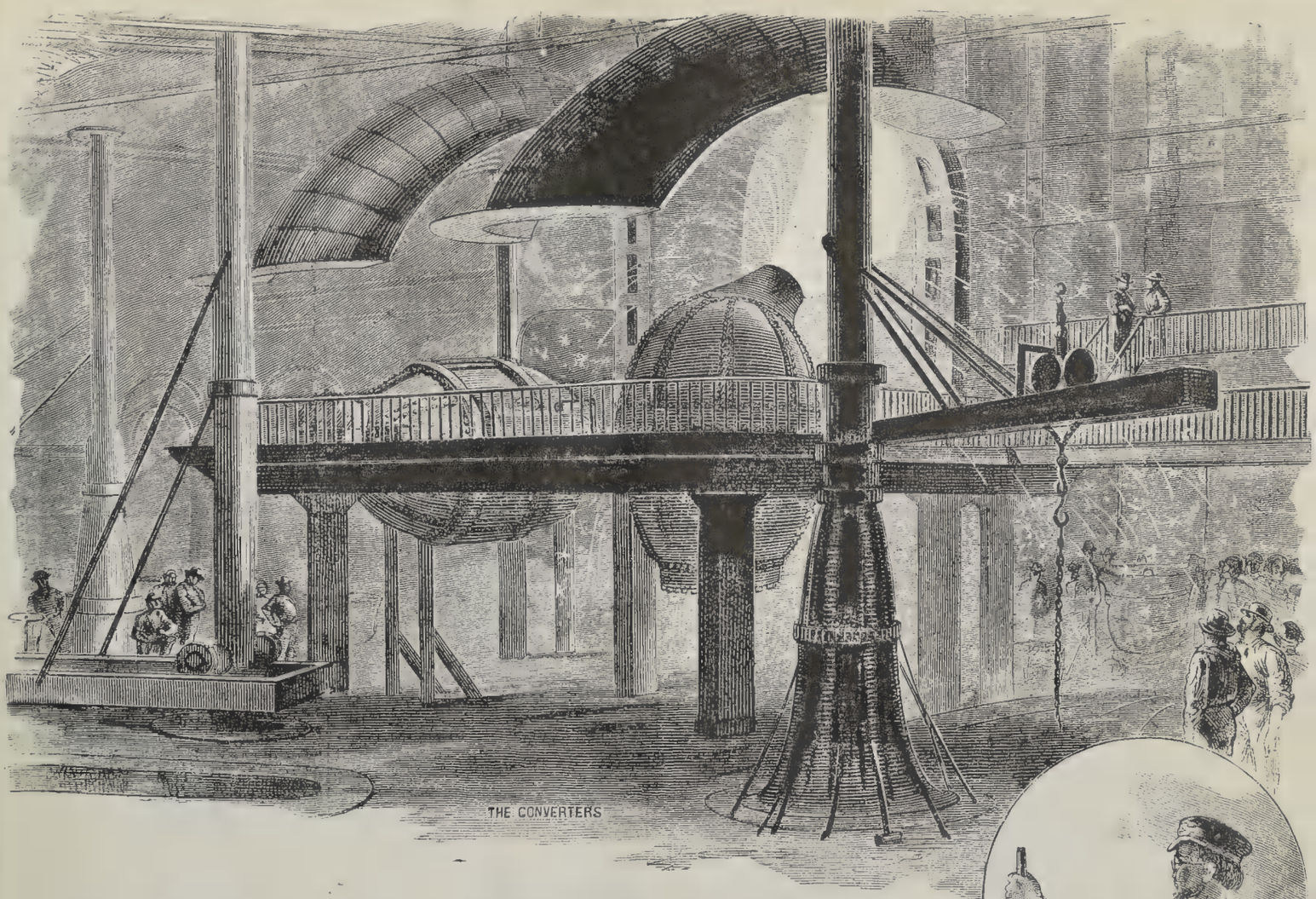
Hipersil steel is here being cut in a slitting machine for use in transformers, saving other scarcer metals

even before he is ready to use them.

Cast to shape tool steel dies, such as those made by the Jessop Steel Company, are a similar case. They take some of the worst burdens from heavily overloaded tool rooms. Punch press dies can be replaced at minimum cost; the fear that these dies might be mishandled and ruined disturbs the sleep of production men far less than it used to. And tool and die troubles do not stand in the way of planning for low cost stamping, drawing, or extruding, the way they formerly did. The cast to shape electric tool steel dies can be finished with a minimum of machining operations, then hardened, and they are ready to mount.

Cast to shape punches, special rolls, knives, and other tools are figuring in hundreds of war product reconversion plans, thousands of post-war schemes. Somewhere along the line the mechanical engineers will ask for qualities which present cast tool steels do not have.

METALS IN WRAPS — Coated metals, such as the copper coated strip steel made by the Thomas Steel Company, are results of dual attacks by metallurgists and mechanical engineers. The metallurgists worked on the alloys and the means of making those alloys





Above, reproduced from an old steel engraving, is one of the first successful converters constructed during the last half of the 19th century.

STEEL AND CRANE CO. STARTED TOGETHER

Ninety years ago, when R. T. Crane opened his little foundry, men were just learning how to convert iron—that age-old metal—into steel.

It is an interesting coincidence that the first patents for making steel were granted in 1855—the year R. T. Crane founded his business. At that time few realized the tremendous part this newly developed metal would play in America's great industrial expansion.

It is a far cry from the simple little charcoal-burning converter of R. T. Crane's time to the giant steel mills of today. And during the years that saw this growth, Crane Co. grew, too—providing valves and fittings that were essential to the vast industrial expansion of the last 90 years.

Today modern industry is inconceivable without valves, fittings and pipe. Crane—the world's largest manufacturer of piping equipment—is a familiar name wherever water, steam, air, oil or gas flows. No matter what the piping system, Crane can equip it 100%.

CRANE CO., 836 South Michigan Avenue, Chicago 5, Illinois

CRANE

90 YEARS OF PROGRESS 1855 1945

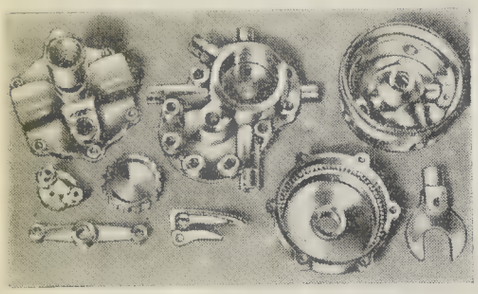
VALVES • FITTINGS • PIPE

PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS

cling together; the mechanical engineers produced the rolling and the coating equipment.

Now that they are here, the coated metals are finding no end of uses. Put two pieces of copper coated steel together, apply heat, and a brazed joint is produced to make a corrosion-resistant assembly. Steel is especially coated to improve welding, soldering,



Mechanical engineering made possible these hot pressed forgings produced by the American Brass Company. They have many advantages over castings

tinning, and plating. Lead coated steel can be drawn to unusually fine dimensions.

Metallizing (spraying of molten metal) is constantly finding new uses with the help of metallurgists and mechanical engineers.

When the process first arrived some 25 years ago, only a few low melting point metals such as aluminum and tin could be sprayed. But mechanical engineers went to work on improving the metal heating and spraying equipment, and metallurgists brought out special alloys which sprayed well.

Soon the process was being used to apply hard surface coatings and stainless steels and bearing metals. Engineers added lathe techniques, tumbling barrel methods, and others to handle the parts being sprayed. Deep threading of parts so that the sprayed metals could take better grips and fusing welding rod to hard surfaces to help the sprayed metals to take hold, are recent helps which the engineer has given the metallurgist. But the metallurgist has new alloys coming along; he soon will be opening new opportunities to the mechanization of metallizing.

At Westinghouse, the mechanical engineer has developed a "millionth of a second" x-ray photographing technique for studying machine parts in action. High speed engine valve stems, for example, are "shot" while in full speed operation. From such pictures the engineers will redesign the valves to give more strength where strength is needed, take out some of the weight, stiffen a section here, and overcome the tendency to bend and distort elsewhere.

Attacking the same problems as revealed by the same pictures, the metallurgist will show how to make the same improvements and get better results by changing the alloys and the heat treatments. Metallurgists and engineers will share the problems between them, and each will challenge the other by giving him new opportunities to apply his art.

Such is the path of mechanical progress. The mechanical engineer makes one kind of attack on a problem, the metallurgist another. Between them the problem is reduced.

⊕ ⊕ ⊕

MAINTENANCE

Costs Railroads Far More than Factories

RAILROAD maintenance bills for the nation as a whole run from 28 to 30 percent of total railroad income. This is just ten times as high—percentage-wise—as the 3 percent or less which is common to large factories.

The total main line railroad maintenance bill for 1943 was $2,546,309,009. This is as big a target as modern maintenance-reducing products ever have had to shoot at. Reduction of this bill, both percentage-wise and dollarwise, will keep the best mechanical engineering brains of our nation busy for many a post-war year. There is practically no mechanical product which railroads do not buy and use, and therefore almost every industry will find a market for its most durable products in the railroad field.

GLASS INSULATION

Increases in Use Through New Applications

IN THE pre-war year of 1938, Westinghouse Electric and Manufacturing Company used $38,000 worth of fiber glass for coil insulation. In 1944 this company used $1,500,000 worth. Nearly all the increase was due to new applications, only a little being accounted for by greater use for old applications.

Glass insulation is permitting the manufacture of dozens of special motors which could not operate if insulated with the materials formerly used. Main benefit of the glass is to allow the motors to operate at higher running temperatures.

INSPECTION TOOL

Provided by Torque Wrench

TORQUE wrenches have scales built into them by which their users can tell the exact amounts of torque which are applied in tightening nuts. Use of these wrenches has added high degrees of precision to the assembling of automobiles, aircraft, and fine machines. But the wrenches are slow, as any hand tools must be. Therefore, assembly departments have built automatic torque control devices into electrical and other powered nut runners, screw-drivers, and similar devices for applying threaded fasteners.

The trouble is, these devices do not have human intelligence. They will stop turning the threaded device at a predetermined number of pounds or ounces of torque but they can be fooled by a speck of rust on the threads, a change in the amount or lubricity of the oil on the threads, slight roughness on a surface, and the like. They do not always tighten the threaded devices to exactly even tensions.

An answer to this is to use powered wrenches for assembly and manual torque wrenches as inspection tools. The inspector may check up every nut, bolt, or screw on an assembly, or he may spot-check a few of them.

Back of the torque wrench is the mechanical instinct, the "feel," the personal know-how of the inspector. It is the old story of mechanical devices never displacing the craftsman, but merely taking from him the drudgery tasks and moving him along to the work which takes brains as well as training.

MATERIALS HANDLING

Expedited by Use of New Angle Rails

GUIDING of dollies, trucks, assembly stands, and other wheeled materials-handling devices to the exact locations desired has long been a materials-handling problem.

If these devices were wheeled along the floors, they tended to create ruts, spall out, or otherwise break up patches of hard flooring materials and do other damage. Furthermore, they could be deflected from straight-line travel or be spotted in such locations as to be hazards to workmen or interferences to aisle traffic.

One answer to these problems has been to roll the wheels on steel tracks. But the tracks brought problems of their own.

An answer to these problems, provided by the Bassick Caster Company, is a flat strip of steel with an angle iron welded apex-upward to one side of it. When the strip is laid on the floor the angle iron becomes a sloping sided track on which grooved wheels can run.

The grooved caster wheels can have wide enough treads on both sides of the grooves so they can be rolled on floor as readily as on the angle irons. Thus trucks which move along these tracks can be removed and rolled to places which the tracks do not reach.

The tracks are not dirt-catching hazards; due to their sloping sides they offer little tripping hazard to workmen; other wheeled traffic can be moved across them.

These angle-iron tracks with the grooved caster wheels to run on them are not "cure-alls" for wheeled factory traffic. There still are plenty of materials-handling problems which are best solved by wheels that roll directly on the flat floors, plenty of others for which the flanged wheel, which is certain to keep on the track, will be preferred. But in these days of dolly and truck assembly-line methods, this new angle on wheeled traffic control is finding plenty of use.

CONGRATULATIONS...



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Drawing It Out Fine

Wire Drawing Today Is a Complex Series of Precise Operations Which Depend Upon Accurate Dies and the Careful Regulation of Lubricants and Drawing Speeds. The Drawing of Fine Wires Necessary in Many Electronic Devices is Expected in Itself to Grow into a Major Industry

By ROBERT L. ZAHOUR

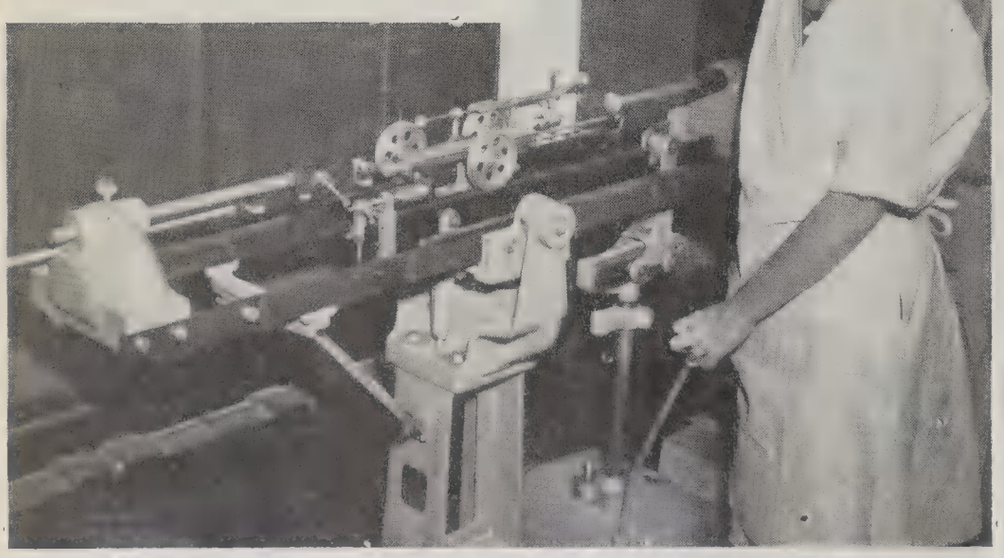
Technical-Commercial Manager, Wire Division, North American Philips Company, Inc.

WIRE DRAWING is an ancient skill. The monk, Theophilus, writing about 1000 years ago, described a wire-drawing die in these words. "Two pieces of iron, three or four fingers wide, smaller at the top and bottom, rather thin, pierced with three or four rows of holes through which wire may be drawn." In those days the work was performed on crude wooden draw benches. Where heavy gage wire was being drawn, the pulling was accomplished by a shaft or drum driven by a water wheel, capstan, or a system of hand levers. Finer wire was drawn through a die by hand from one drum to another. Small dies were made by piercing holes of desired shape and diameter in a steel plate. Larger ones were made in two metal sections held tightly together with metal bolts. Butter or lard was used for lubrication.

By 1270 A.D., eight wire-drawing establishments were operating in Paris. Apprentices learning the art worked for 12 years without pay before they were rated as masters of the trade. Even then, the law would permit them only to manufacture wire in Paris and sell it within the borders of France. Much of the drawn wire was used in making sleeves for coats of mail worn by knights.

In 1350 A.D., Rudolph of Nuremburg, Germany, established a wire-drawing mill which he extravagantly claimed to be the first in the industry. The modern industry of wire drawing, however, began in Denmark in 1564 when Queen Elizabeth and Queen Anne authorized wire-drawing mills in order to make pins for the royal household. Earlier, pins had been hammered from thin metal strips.

In America, the wire-drawing industry began in 1666 when Nathaniel Robinson of Massachusetts applied to the Commonwealth for financial assistance and permission to start a mill. He was turned down. Similarly, in 1667, Joseph Jenks applied and met with a refusal. In 1775 Nathaniel Niles set up the first wire-drawing mill in Norwich. Two years later, White and Hazard started a plant in Pennsylvania. From that time on, the industry progressed rapidly throughout the nation. Today, wire ranging from heavy cable to sizes below .001 (made of various metals and alloys) has become a vital part of our daily life.



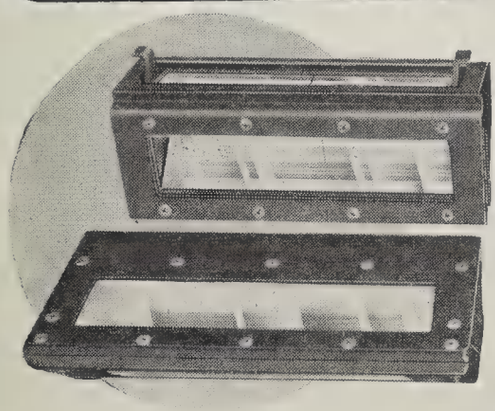
This Scott tester measures the elongation and tensile strength of fine wire

DRAWING FINE WIRE—Many critical factors must be considered when fine wire is drawn accurately and uniformly round to narrow physical and electrical tolerances. In general, these factors cover selection of proper lubricants and diamond dies, careful regulation of drawing speeds and annealing processes, as well as exacting determinations of draft—reduction—of diameter. Many refinements have been made to accomplish greater precision in physical and electrical characteristics of fine wires. This is particularly true where narrow tolerances must be met in electronic applications. A modern motor-driven machine for drawing fine wires is equipped with 16 or more dies arranged in alternate series. Wire to be drawn is pulled through the dies by means of coned pulleys and is spooled at its smaller diameter—all within a few feet of space. For some types of fine wire the draft (or reduction) through each die is approximately .0003 inch. One machine, for example, can draw from .0046 inch to .0012 inch at a speed of nearly 3000 feet per minute. However, this toler-



A long channel die is used for drawing fine, hard wires. The one shown here is magnified about 40 diameters

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6017-S	12	80	Cemented	50¢
6018-S	15	41	Uncemented	40¢
6019-S	15	41	Cemented	60¢
6020-S	18	49	Uncemented	50¢
6021-S	18	49	Cemented	60¢
6022-S	25	95	Uncemented	50¢
6023-S	25	95	Cemented	75¢

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The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

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Stock #3004-S..SILVERED TANK PRISM— Price $2.00 each Postpaid. Illustrated Booklet on Prisms included FREE.

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able reduction will vary, depending on the hardness characteristics of the metal alloy. In general, fine wires have a small reduction per die while larger wires are given heavier drafts.

Since some wire alloys harden faster and create more heat and die-wear than others as they pass through the dies, hard alloys must be drawn at speeds slower than those for soft ductile metals. For this reason, drawing speeds for different wires vary from 100 feet to 5000 feet per minute.

Accurately drilled diamond dies are



An operator threads wire through one of the several diamond dies on a modern power-driven wire drawing machine

carefully selected for the type of wire to be drawn (hard or soft), and are held in rectangular boxes constructed to permit constant circulation of pumped lubricant around each die. This method minimizes die wear since it provides constant and thorough lubrication of the dies at all times and carries away much of the heat generated during the drawing operation.

COLD WIRE DRAWING—With the exception of molybdenum and tungsten, most fine wire alloys are drawn cold. In other words, they are given no preheating auxiliary treatment before the wire enters the die. Careful preparation of dies and selection of effective lubricants is therefore extremely important. Here are a few pertinent facts:

(1) In manufacturing diamond dies, a great deal of attention is given to drilling the channel. For drawing hard alloy wire, the channel is made long and narrow. For softer, more ductile metals, the channel is short and wider. Care and skill must be applied in shaping the channel so that wire of a given hardness can be drawn with the least die-wear and wire breakage.

(2) In drawing fine wires of .002 inch diameter and smaller, the reduction seldom exceeds .0002 to .0005 inch for each die. Particularly where ductile metals are involved, heavier drafts may develop non-uniform diameters due to excessive elongation or stretch.

(3) Channel walls of the die must be polished smooth and must be absolutely circular. A die that is defective in this regard will impart a rough, scratched surface to the wire and produce wire of non-uniform diameter.

(4) Use of proper lubricants is extremely important so as to avoid rapid die-wear, heating, and hardening of the wires drawn. In drawing wire of a large diameter, fatty or heavy oil emulsions are used. For fine wires, light lubricants (such as soap and water) are constantly applied. Hence, the size of wires drawn, their degree of alloy hardness, and drawing speeds all have a definite bearing on the choice of lubricant.

(5) Some alloys harden quite rapidly after passing through a few dies. For this reason, the wire will soon break if not annealed. Where this condition develops, as in the case of resistance wires, the metal must be annealed. This is done in a specially constructed oven that utilizes a reducing atmosphere coördinated with constant temperature regulation.

CHECKING FOR TOLERANCES—Even the slight or varying pressures exerted by a micrometer, when used for measuring the diameter of fine wires, introduce a large percentage error. This usually results in exceeding permissible tolerances. Hence this method is never used. Accurate measurements are made by means of a precision torsion balance that is calibrated to measure to 0.2 milligrams or less. A unit length of fine wire is weighed on this balance and average diameter is computed from weight and density of the alloy. Roundness of the wire is checked by viewing a cross-sectional area through a micrometer microscope.

Tensile strength and elongation characteristics are measured on a Scott tester which charts the results on a card. This information is very vital in determining rapidity with which fine alloy wires harden when drawn through a series of dies. Thus, the drawing operation may be regulated to allow for annealing stages in the entire run. Failure to recognize this alloy-hardening property will cause much die-wear and wire breakage. Then, too, the customer's specifications frequently call for definite elongation limits in the finished wire. These requirements must be met with proper annealing followed by tensile and stretch tests.



Ohmage of resistance wires is accurately checked on a Wheatstone bridge

Fine resistance wires, used in the manufacture of precision resistors for electronic devices, must be held within specified tolerances in ohms per linear foot. As the wire progresses through various drawing stages, periodic tests are made. A sample, accurately cut to one foot of length, is measured on a Wheatstone bridge.

The rapid advances in recent years in the field of electronics have greatly increased the demand for precision-manufactured fine wire products. It is safe to predict that this field of the wire-drawing technique will soon become a major industry in itself. In this development it will make a great contribution to the new ways of production and of living that the increasing application of electronics in industry will bring to the world.

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FUNNYISM

Results if Designers Do Not Understand Engineers

"ENGINEERS must know more about and give more attention to esthetics in design and be ready to work with the modern architectural or industrial designer," said Professor J. K. Finch, Renwick Professor of Civil Engineering and Associate Dean of the School of Engineering at Columbia University, in an address delivered recently before the Metropolitan Section of the American Society of Mechanical Engineers. "At the same time," Professor Finch stated, "the modern designer certainly must know more about engineering unless he is satisfied to create a false, make-believe, pseudo-functional type of design."

In a paper entitled: "The Evolution of Design," Professor Finch said that the modern trend in design involves both the engineer and the artist, but it "very clearly originates in the approach and methods of the engineer. The modern designer—industrial, architectural, or artistic—cannot undertake functional design with success unless he has a keen and clear understanding of the engineering approach to design. Functionalism leads only to funnyism unless it is based on understanding."

VISUAL STANDARDS

Should be Raised for Post-War Jobs

PROMINENT among the many problems of readjustment to post-war jobs that will face millions of men will be that of visual handicaps, points out M. J. Julian, president of the Better Vision Institute.

"In striving for more efficient production, industry increasingly is paying attention to job qualifications of individual workers. After the war there undoubtedly will be carried out extensive screening of employment applicants in many fields of endeavor," says Mr. Julian. The visual abilities of workers

will receive closer scrutiny in the selection of men for jobs. It is now recognized that sight qualifications of workers often have an important influence upon productive output.

"There seems to be little question that industry generally will raise visual standards and that workers with neglected eyesight in the competitive post-war period of readjustment will be forced to tune up their eyes to get and to hold jobs.

"Besides a demand for sharp vision for the general run of jobs, workers with above-average visual skills will be sought for certain specialized tasks. Greater attention will be paid to choosing workers with good eye coördination, or muscle balance, for jobs that require precision workmanship, or which call for long periods of close focusing. In some factory operations, persons with poor muscle balance are hazards to themselves and other workmen.

"Depth perception is another visual skill that will be sought in the eyes of men working around moving machinery. Depth perception is the ability to judge distances and the relative position of objects. It is very desirable in truck drivers.

"On some jobs good color perception is essential, both for safety and productive efficiency. Unfortunately," continues Mr. Julian, "there are many men who cannot distinguish colors easily. While eyes can be sharpened with glasses to see clearly, relatively little can be done for color-blindness, which is a hereditary condition. Even so, visual training is said to improve the ability of some color-blind persons to distinguish colors.

"Very probably more attention also will be given to the seeing habits of workers. Persons have habits or patterns of seeing just as they have habits in holding tools, or gaits in walking. Efforts will be made to coördinate desirable patterns of seeing with certain jobs. For example, some persons see things faster than others. Slow eyes that might be entirely satisfactory for a clerical position would be unsuitable in many machine operations.

"After the war," concludes Mr. Julian, "America undoubtedly will strive for new goals of productive efficiency. Eyes right for the job will be needed by the post-war worker."

BEAUTY BUSINESS

Will Build Firmly on Lowly Coal

A BILLION-DOLLAR post-war business in women's daytime and evening apparel, accessories, perfumes, and cosmetics, all stemming from coal by-products, was presaged recently at a preview of advance fabrications given by the Bituminous Coal Institute. The theme of the showing was a forecast of the future availability of such personal feminine luxuries as softer lingerie, frillier dresses, sheerer hosiery, lighter weather-proof outer wear, and finer costume jewelry to almost every woman, through reduced manufacturing costs made possible by the chemical transformation of coal and its by-products into women's apparel and articles of adornment.

A feature of the exhibit was a filmy dance frock, fashioned from a chiffon-like material derived from coal and chemically treated with its by-products to make the dress wrinkle- and spot-proof. Silk and rayon fabrics similarly treated to render them water- and fire-proof as well as wind-resistant also were displayed.

Woolens, made moth- and shrink-proof with coal derivatives, attracted special attention. When so treated, it was reported that the finest woolens can be washed with cottons and other materials without shrinkage. The treatment is said to be permanent and to make no appreciable change in the appearance, texture, or warmth of the fabric while the color fastness and wearing qualities are stated to be improved.

Many new plastics, reported to be less brittle, stronger, and more heat- and wear-resistant than any previously produced, have been developed primarily for military purposes. Although the widespread civilian use of such materials must wait until the end of the war, shoes having plastics tips, soles, and heels already are obtainable.

To demonstrate the hardness and permanence of plastics finishes, a table with a surface made from coal derivatives was used as an ash tray by guests at the exhibit. This was pointed up as a promise of the durability of new laminated plastics-bonded furniture soon to be available.



The Spark that Lights the Flame of Victory



A pinpoint of fighting metal placed in the arc of the spectrograph writes its own signature on a photographic plate. Inside the instrument, the light from that flame is broken up by a prism as a prism breaks up sunlight. Each element identifies itself by a series of characteristic lines, always the same for the same basic element. It reveals to the spectrographer each constituent, what impurities are present and in what quantities.

Thus spectrography helps in control and inspection. It keeps tough fighting steels tough, helps in development of new fighting metals. Spectrography is used, too, in other fields to speed research and analysis... chemicals, foodstuffs, vitamins

Because Bausch & Lomb had long experience with such precision optical equipment, it was ready for quantity production of gunfire control instruments, binoculars and aerial photographic lenses. When the last gun is fired, Bausch & Lomb will devote its enlarged experience to peacetime optical production. Bausch & Lomb Optical Co., Rochester 2, N. Y.

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New Products and Processes

PHENOLIC RESIN

Aids in Producing Hard Synthetic Rubber

ONE of the toughest problems confronting the synthetic rubber industry is the processing of synthetics to reproduce the characteristics and properties of hard and semi-hard natural rubber stocks. Chemical science has now found an answer to this problem. Research engineers of the synthetic rubber manufacturers and the plastics industry have evolved a method of processing most synthetic rubber with a Durez phenolic resin whereby very excellent hard and semi-hard rubber stocks can be produced. To date the use of this resin has been confined to Buna S and Buna N, but it is known that the resin is compatible with neoprene and also with natural rubber. Its use with other synthetics is being investigated.

The Durez resin which has been formulated possesses the very useful characteristic of softening synthetic rubber during the milling or processing of semi-hard and hard rubber compounds. Because of the peculiar stiffness of synthetic rubber as compared with that of natural rubber during such processing, it has been extremely difficult to add sufficient loading during milling to produce the semi-hard and hard rubber stocks. In the production of these stocks from natural rubber this loading with reinforcing materials such as carbon black was not a problem because of the natural plasticity of the rubber on the mill.

The Durez resin, being thermosetting and completely compatible with the synthetic rubber, also reinforces the rubber in much the same manner as carbon black. It therefore produces stocks of high tensile strength, a high degree of hardness, good elongation, and low-temperature flexibility. Depending entirely upon the amount of resin used, the amount of reinforcing agents normally required to give a definite hardness can either be entirely eliminated or reduced proportionately.

PREHEATER

Warms Buses on Cold Mornings Before Passengers Get Aboard

AFTER standing overnight in zero weather, buses now receive a quick boost in temperature from a "Janitrol" portable heater of the type developed to preheat airplanes at Alaskan air bases.

Comfort for passengers on the first run is the object, and, according to Surface Combustion, manufacturer of the unit, the interior of a cold bus can be warmed to a degree pleasant to riders within five minutes before the first trip is started.

Gasoline, kerosene, or light oils, including Diesel oil, can be used as fuel for the portable unit, which has an output sufficient to warm four average-sized homes. Its heat rise of 230 degrees enables it to deliver positive heat in sub-zero temperatures.

NEOPRENE RUBBER

Will Be Widely Used In Home Applications

RELEASE of neoprene from war's demands is expected to bring greater durability and practicality to many household products. Sponge cushions and mattresses, tile-like flooring material, carpet backing, and numerous structural parts for household equipment are named as possible applications of this synthetic rubber. Its return will also again make available such pre-war items as household gloves, sink strainers, mats, and crib sheets.

Sponge rubber cushions, upholstery, and mattresses made of neoprene by a new process remain firm and even, and have long life. Foam sponge, as it is called, is made by converting rubber latex into a foam and setting it to form a sponge-like mass of any desired shape and degree of springiness. Neoprene foam sponge, unlike that of natural rubber, can be made flame resisting. While it will burn in contact with flame, it ceases to burn when the flame is withdrawn.

Another type of mattress material in tomorrow's home will be made of goat's hair and neoprene. In making this mattress, an open mesh is formed by bonding goat's hair with neoprene latex. The mesh is folded to form a spring layer about an inch in thickness. Several layers of this material are built up to the desired thickness.

A durable backing for carpets and rugs will be made by applying neoprene cement to the floor side of rugs, firmly anchoring the nap in place. The coating, which is especially valuable for the commonly used "U"-shaped naps, adds but little to the over-all cost of the rug. The use of neoprene will permit cleaning with solvents that would readily attack rubber backings.

There is also prospect of a new type of terrazzo flooring made by stirring marble chips into colored neoprene latex, pouring the mixture over the floor foundation, and troweling it down. Satisfactory installations in shipboard shower stalls, staterooms, and galleys indicate that this tile-like flooring may be adaptable to home bathrooms, cellar playrooms, kitchens, swimming pools, and terraces.

While neoprene will still be a premium priced product, as compared with natural rubber, the premium will be substantially less than before the war, due to increased production and the fact that rubber manufacturers have gained more experience in processing the material.

TIGHT-SPOT CELLOPHANE

Proves Useful in Electrical Insulation

CELLOPHANE so thin that it would take approximately 1000 sheets to make a pile an inch high is finding increased use in industrial tight spots, where a space-saving wrapping material is re-



High-efficiency heater rapidly warms a bus

quired, according to Sylvania Industrial Corporation, which manufactures this very thin cellophane. The material goes into wrapping wires in electric cables, where it not only saves space but acts as a fire retardant as well, the company reports.

Cables of this kind were originally designed for airplanes and needed to be as small and compact as they could be made. Since each cable contains several individual wires, the material for wrapping each wire had to be as thin as possible, and still be tough and durable enough to withstand hard industrial use. This thin cellophane proved so satisfactory in the air that it is now extensively employed in Navy cables as well. Because it saves both space and weight it is expected to find ready use in other wires and cables, so that the maximum number of them can be placed in the metal conduits that lace the walls of modern office buildings and twist their way beneath the streets.

One of the many different types of cellophane that have been developed to meet the requirements of specific industries, this very thin sheet does the required space-saving job, and in addition acts as an aid to insulation inside the cable, protecting the covering of the wire from the asphaltum which surrounds it. Since the cellophane is manufactured in different colors, it is also used as a coding device inside the cable, each color indicating a different strand of wire.

HEAT RESISTANCE

Increased in New Plastics Formulation

A NEW molding compound of "Lucite" methyl methacrylate resin, combining heat-resistance 30 to 40 degrees, Fahrenheit, higher than general-purpose powders with other desirable properties previously unobtainable in a single formulation, is announced by the Plastics Department of E. I. du Pont de Nemours and Company.

The new formulation, designated as HM-122, is outstanding for ease and economy in molding, the company says. Its faster setting properties, when properly heated dies are used, contribute to a shorter molding cycle. The material from this new formulation has added resistance to breakdown from heat at molding temperatures, producing not only better moldings but improved clarity.

The entire output of formulation HM-122 now is allocated to essential uses, such as colored caps for switchboard light signals, parts for sextants and stethoscopes, blackout lenses for military vehicles, airfield landing light lenses, relay box covers, battery adapters, and control wheel knobs.

Moldings of the new "Lucite" are distinguished by unusual clarity and brilliance. They also possess excellent reflecting properties and are exceptionally free of distortion when molded properly. This new formulation can be obtained in a wide range of transparent, translucent, and opaque colors for both indoor and outdoor use.

Though not "boilable," the material produced from this new formulation may be used in many installations where substances with a lower heat-distortion point would fail.

LEATHER-LIKE PLASTICS

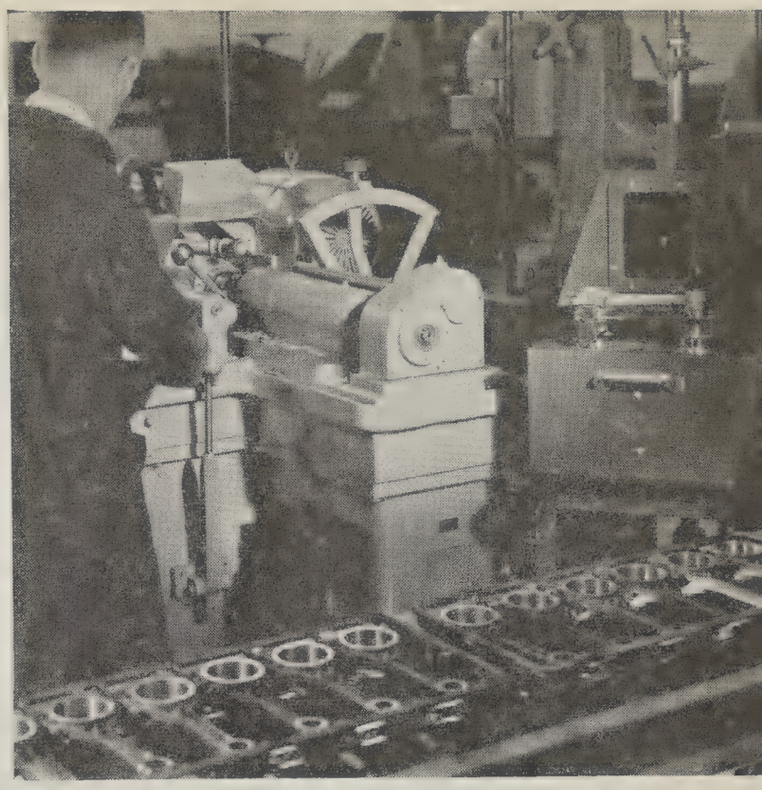
Has Many Uses As Covering Material

A NEW leather-like plastic that has great resistance to abrasion and scuffing has been announced by the Firestone Tire and Rubber Company.

Called Veloflex, the new material has a vinyl base. It will be produced as a sheet or coated fabric in a large number of surface patterns such as cowhide, alligator, boxed calf, pin-point morocco, and new designs. In addition to its patterns, it can be produced in various weights and thicknesses and in any shade or color.

Completed laboratory tests, according to Firestone, have shown that the tensile strength of the new plastics is from 2000 to 4000 pounds per square inch and elongation from zero to 30 percent. In flexural strength, it has withstood more than 3,000,000 flexes without cracking. The new material is an excellent non-conductor of electricity. It resists acids, alkalis, and organic solvents and will not absorb moisture.

The field of uses for Veloflex includes luggage, upholstery, men's and women's purses, desk tops, book bindings and covers, water-proof cases



A connecting rod operation in the great American Automobile industry in Michigan. To the right, an EXACT WEIGHT Shadograph in the act of balancing a connecting rod.

Why Quiet Reigns under Your Hood .

That smooth running motor of yours . . . quiet under th hood . . . it's no accident. Rather it is the result of years of pe fect blending of skilled labor and precision tools, the combina tion which has made America great in the metals industry. Pi tured above is a connecting rod milling and checking operatio An EXACT WEIGHT Shadograph Scale guides this craftsma by weighing the connecting rod, the heavy and light ends simu taneously to a given tolerance set by engineers. Such an opera tion makes connecting rods all alike. When six go into your ca of equal weight motors run smooth . . . quiet reigns under th hood. This is but another of the thousands of applications fo EXACT WEIGHT Scales in American Industry, proven to b the best in the world.

INDUSTRIAL PRECISION

Exact Weight Scales

THE EXACT WEIGHT SCALE COMPAN

65 West Fifth Ave., Columbus 2, Ohio

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shoe uppers, gloves, clothing, military kits, pads, seat covers, and many more.

This new material can be sewed, heat-sealed, or cemented. Water and dirt can be safely removed from it with a damp cloth or with ordinary cleaning fluids.

GRANITE SURFACE PLATES

Will Not Warp
Or Distort

SURFACE plates employing black granite, a material that is molecularly inert, cannot be warped or otherwise distorted by any conditions to which a surface plate is normally subjected.

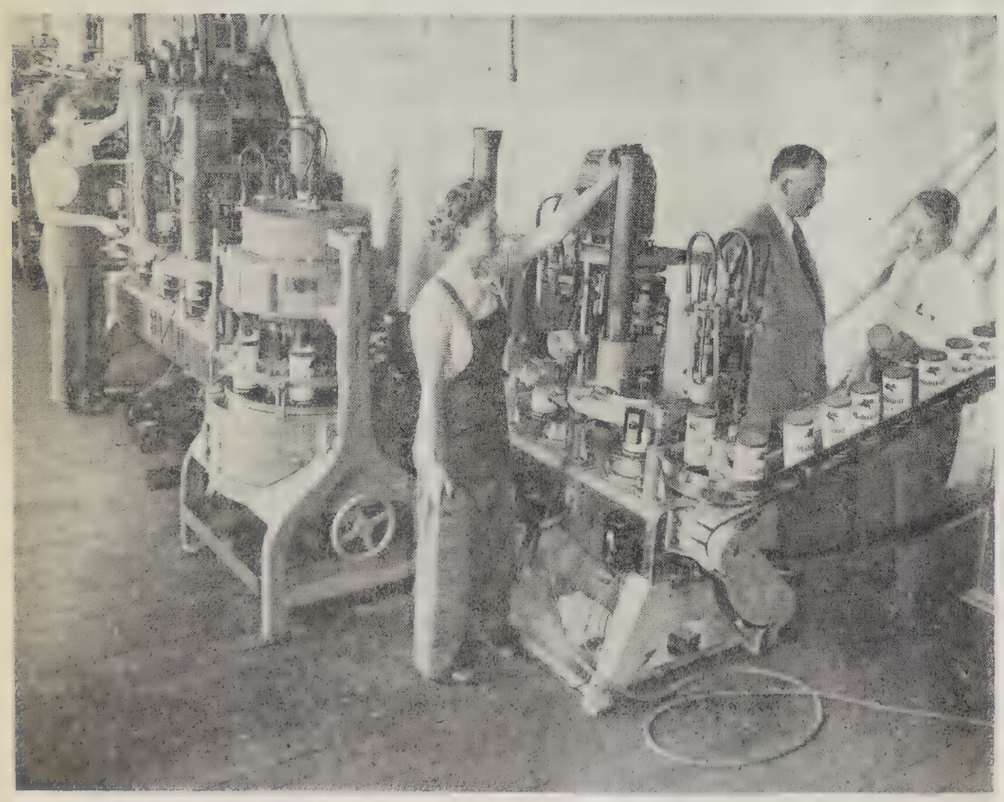
These Velsey surface plates, as they are called, are lapped in series to a tolerance of .00005-inch surface flatness which is never changed by shock or temperature fluctuation. The material is harder than tool steel and consequently cannot be scratched by instruments. Even if the surface were nicked by a heavy blow, the adjacent material would not be upset. The base of an instrument would surmount the nick without affecting the precision of measurements. It is claimed that these surface plates will last for many years since they do not corrode, abrade, or warp.

LUBRICATING OIL

Now Packaged in
Paper Containers

LUBRICATING oil is now being packed in one quart paper containers at the rate of 70 quarts a minute by high-speed packaging machinery. Perfection of the packaging method breaks a bottleneck of metal shortages, since the paper container is made entirely of non-critical materials, the paperboard used being exempted from the Government's container limitation order. The container is weather-proof and oil-proofed on the inside. In appearance and service, it is similar to the ordinary metal container.

The high-speed packaging machine, a product of the Package Machinery Company, is set up in combination with standard paper working equipment to complete the process from fabricating the container to filling and sealing it. The paper working equipment takes ordinary board paper in roll form and, in combination with adhesives, spirally winds it into a cylinder, open at each end. The packaging machine itself consists of three units: bottoming, filling, and closing—all completely automatic.



Paper containers of lubricating oil are packaged on this assembly line

PLASTICS MOLECULES

Measured Accurately
By New Instruments

AS A first step in providing the plastics industry with a better method of investigation through sorely needed standard instruments for quick determination of the size and shape of molecules, two instruments have been constructed in the Highpolymer Laboratory of the Polytechnic Institute of Brooklyn. These instruments for the first time offer a direct visual procedure for determining the shape of molecules and a short cut for determining the weight of polymer molecules. The most important processes for manufacturing various types of rubber, plastics, and fiber are extruding, molding, casting, and spinning. To produce the best results, it is necessary to know the size and shape of the molecules of which the material is built. At present, chemists use viscosity as a rough criterion for these fundamental properties but this method is far from being satisfactory.

The two new instruments, the turbidimeter and the rayleighometer, based on simple visual observations, employ the scattering of light to learn about the size and shape of large organic molecules such as those used in making tires of synthetic rubber, lenses of synthetic resins, and stockings of synthetic fibers.

The principle of light scattering was discovered in 1910 by Dr. Albert Einstein, originator of the Einstein theory of relativity. In 1943, Dr. Peter Debye,



Pipetting a sample of a test solution into the chamber of the turbidimeter

of Cornell University and a Nobel Prize Laureate in Chemistry, discovered how to use this principle to compute the molecular weight and shape of giant molecules and proved that it had a practical application. As a result of these findings, it has been possible for Dr. Paul M. Doty, research associate and instructor in physical chemistry at the Polytechnic Institute, in collaboration with Dr. Herman F. Mark, Polytechnic's professor of organic chemistry, to design an instrument, a kind of photometer, which allows a quick and reliable measurement of the light scattered, by spinning and casting the solution in various directions. Eventually it will be possible to use this method in industry on a routine standard basis to produce fibers of high fatigue resistance, plastics of high impact strength, and rubbers of high endurance against abrasion.

COLOR DETECTIVES

Provide Precise Tool for
Industrial Chemists

CHEMICAL color-detectives so powerful that they can detect iron atoms forming only one part in 1,000,000 parts of water were described to the American Chemical Society recently by Prof. G. Frederick Smith of the University of Illinois.

These color-detectives, used in analyses in a number of important industries, are organic reagents—organic ring nitrogen compounds known chemically as orth-phenanthroline and substituted phenanthrolines.

Their most important property is their ability to react with a number of divalent metal ions—electrically-charged atoms—such as iron, cobalt,

copper, nickel, zinc, chromium, and ruthenium.

Three molecules of one of these compounds, Prof. Smith explained, will react with one divalent iron cation, a positive ion, to form an intensely red water soluble product.

A minute amount of this product can color "a comparatively enormous amount of solution to which it is added. The presence of one part of iron in this form is easily detected in the presence of 1,000,000 parts of water."

One milligram of iron can be detected by its color in one cubic meter of water by another color-producing compound, and one ounce of iron converted to this complex "would color to a discernable hue the water displaced by a battleship."

Prof. Smith said that this type of compound also can be used as reaction indicators by changing their red form to a blue form. "The change in color is vivid, precise, and reversible. At the point of color change, the chemical reaction being carried out is shown to be complete."

These compounds are used in various kinds of analytical work in iron and steel production; special alloy steel manufacture; rock ore and mineral utilization; limestone, cement, and glass technology; and drug, medicinal, food, and wine processing and preserving.

COMPAR LINING

In Sandblast Cabinets is Better Than Boiler Plate

FULL-TIME operation of sandblast cabinets has been made possible by an application which was first tried out to protect the perforated bottom of a



Compar lining protects bottom of sandblast booth, as well as the parts tray

much-used device of this kind. Experience had shown that the force of the steel grit, driven over the parts in the cabinet under 90-pound pressure, quickly wore through the boiler-plate which was the customary protective covering, necessitating frequent replacement.

A sheet of compar, the plastics developed by Resistoflex Corporation, fastened securely to the bottom of the cabinet, proved the solution to the problem, with a resistance to abrasion said to be 250 times that of the boiler-plate, assuring continuous operation for several months with no stoppages for replacement. Likewise, the wood-tray which holds small parts to be sandblasted is covered with a sheet of flexible compar. Although this tray is held directly below the nozzle, the compar covering shows no wear after months of continuous use.

ADHESIVES

Are Important to a Number of Industries

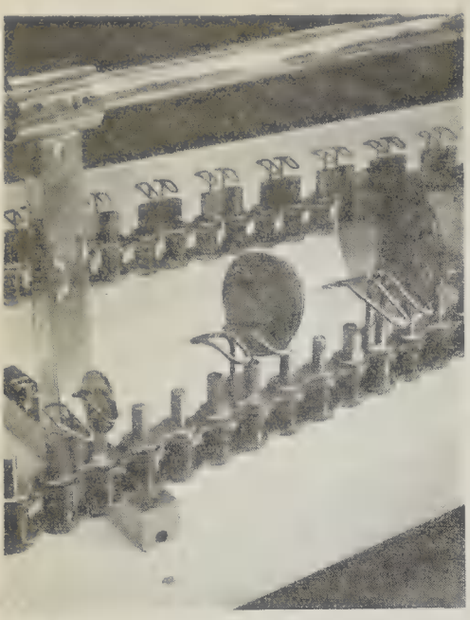
ADHESIVES derived from starch enter into the manufacture of an almost limitless variety of products, according to Lee T. Smith and R. M. Hamilton of the Eastern Regional Research Laboratory.

Starch adhesives were used by the Egyptians. In the latter part of the 18th Century, the manufacture of starch adhesives and sizes became important in industry. In the United States the growing need for starch was realized by John Biddis of Pennsylvania, who devised a method of manufacturing starch from potatoes and was granted a patent in 1802.

The introduction of postage stamps in 1840 and the subsequent invention of gummed envelopes stimulated the demand for adhesives.

About the same time the development of photography created new uses for adhesives in mounting photographs. The introduction of matches offered another use for adhesives in the manufacture of the cardboard match box. Through the use of the cardboard tubular cartridge, adhesives aided in revolutionizing the shotgun from the muzzle- to the breech-loader type





Above: Special clips hold different size filters on the conveyor belt of the automatic laminating equipment. Right: Placing filter blanks between glass. The resulting "sandwiches" then go to the automatic laminator

From this beginning, tubes for various purposes were developed.

The introduction of the paper bag was the first step toward modern packaging. The almost instantaneous sealing of paper seams made possible the high speed of the adhesive sealing machines.

PRECIOUS METALS

Recovered from Waste Fluids By Anion Exchange

A PROCESS by which valuable and war essential metals may be removed from waste solutions by absorption on anion exchange resins was announced at a recent meeting of the American Chemical Society. While primarily intended for the recovery of scarce and valuable metals now being lost in waste waters, the new method is also expected to be beneficial in reducing stream and harbor pollution in the vicinity of electro-plating and other metal working plants.

According to chemists of The Permutit Company, anion exchange resins, under special conditions will completely absorb certain metal salts from very dilute solutions. When complete absorption is no longer obtained, the resins are treated with appropriate chemical solutions to effect recovery of the metals in the form of solutions which may be 25 or 30 times as concentrated as the original waste liquors. The anion exchange resins undergo no permanent change in the process and may be re-used indefinitely.

LIGHT FILTERS

Made Automatically by Ingenious Equipment

AUTOMATIC laminating equipment, developed initially to meet the increasing demand for laminated filters to be used as lenses in the Polaroid Dayglass, has proved valuable in the production of many other kinds of light filters made of a combination of glass and plastics.

In one continuous automatic operation, the equipment manufactures a continuous roll of adhesive material, adheres it to both sides of a plastics sheet, and stamps out the adhesive plastics in the desired shape and size. The stamped plastics travels on a belt to a wheel where operators sandwich it between two pieces of glass. The sandwich is carried automatically to



be pressed and then conveyed by belt to quality control inspectors.

Over 30 million filters of a variety of shapes and colors, polarizing and non-polarizing, have been turned out on this equipment, which is reputed to have produced by far a greater volume of light filters than any other production unit occupying a comparably small area.

The filters are used in conjunction with many military aiming and sighting devices including bombsights, sextants, binoculars, and gunsights. They eliminate reflected sun glare, penetrate haze, permit the viewing of three-dimensional vectographs, and perform a number of other tasks affording increased vision.

MOLDING PRESS

Uses Electronic Heat on Thermosetting Plastics

A VERTICAL hydraulic "hyspeed" press that molds plastics items and utilizes electronic heating of the plastics material to effect sensational economies in production time, has been announced by Ralph Kelly, president of The Baldwin Locomotive Works.

Held secret until now, experiments have been conducted for months by The Bryant Electric Company on ureas and melamines, vital to the process. Also working with Baldwin's Southwark Division to create the method were Westinghouse Electric and Manufacturing Company and Monsanto Chemical Company.

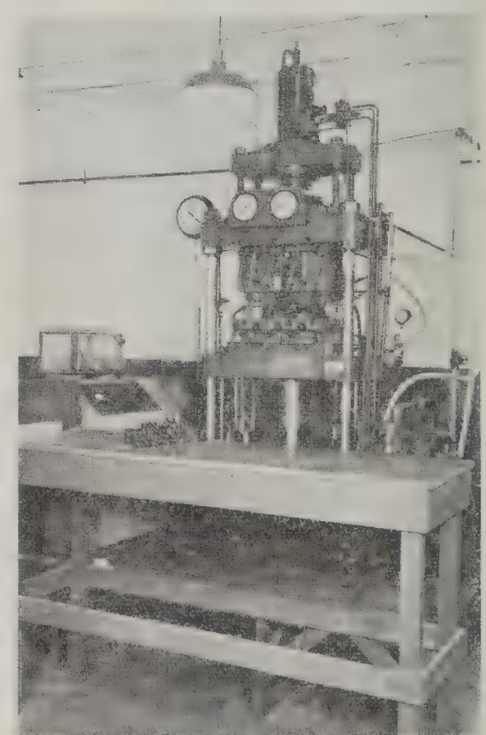
The first electronic heating unit and forming press, set up to operate manually, have proved entirely successful, according to Charles J. Smith, head of the Plastics Division of the Bryant Electric plant, which built special molds for the experiment. He said that "high frequency heating is a proved success on small parts." The plant, he added, has been able to reduce the curing time on a particular product from minutes to seconds.

"By reducing this time, workmen have been able to turn out 20 percent more pieces from an experimental six-cavity mold than were previously turned out from a standard 24-cavity compression mold." Mr. Smith estimated the mold savings in this one experiment between the six-cavity and the 24-cavity molds, at $6000, in addition to a 12½ percent saving in plastics materials since the Baldwin-designed press does a precise extrusion job.

Smith said the method of squeezing the preheated plastics into the mold and changes in mold design make high-speed thermosetting molding practical. Therefore, the production from a small press with a small number of cavities is just as great as, or greater than, that of a large compression press with a large number of cavities.

In the first production experiments, one workman operated both the two-kilowatt heating unit and the molding press. The plastics, in the form of thick wafers, was placed in the heating device where it was exposed to short-wave radio beams for a few seconds. Then the workman lifted out the hot wafer, transferred it to the press, and a plunger forced it down against the mold. It remained only a few seconds under pressure of six tons per square inch, then was released. When removed, the particular product in this case turned out to be a series of clean, shiny plastics electric outlet plugs such as the average American is accustomed to buy in the appliance department of any store.

Because the heat is established inside the preforms as quickly as outside, there is no opportunity for the outer portion to overcure before the inside gets hot. Because the preforms go into the mold hot, much lower pressures



Heating equipment and molding press that economize on production time

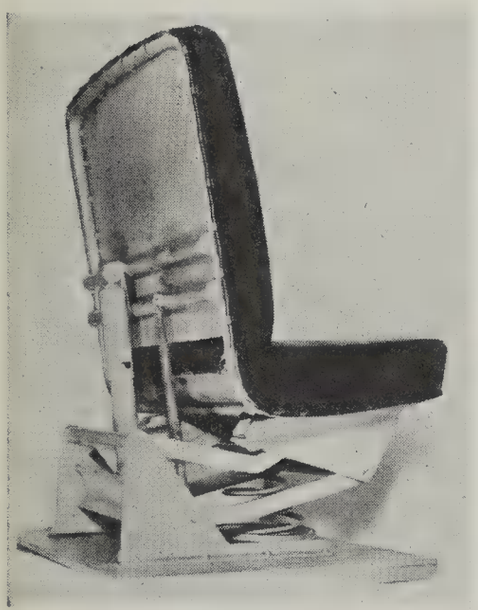
can be used. This means smaller presses. It is estimated, as a result of lowered pressure that, for a particular job, the press would cost approximately one third as much as a straight compression press; that maintenance costs would be reduced to a fifth; and that the molds would have 30 percent longer life.

TANK SEATS

Adapted for Trucks to Permit Smoother Driving

RELIEF from fatigue and the danger of falling asleep at the wheel has become possible for truck drivers as a result of the war-time production of more than 200,000 tank seats for the armed forces of the United Nations. At the request of truckers, who had learned of the level, comfortable ride made possible by the tank seats, the Monroe Auto Equipment Company, manufacturer of the seats, adapted them for use in trucks.

The truck seat features a variable-rate coil spring which reacts equally to a large man or a small boy. A long auxiliary spring, used in conjunction with a double-action hydraulic shock absorber, limits the height of

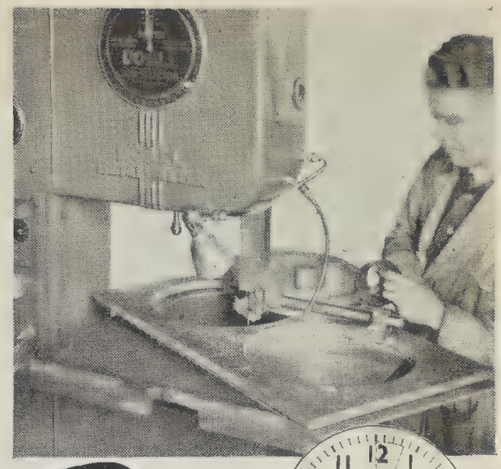


The spring has a variable rate

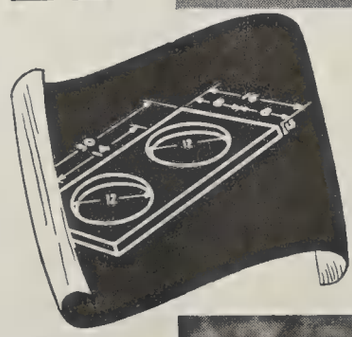
the seat in the free position and affords a resilient limit to its action.

The shock absorber, resisting any sudden or sharp action of the spring due to travel over bumps or rough roads, levels off the ride regardless of jolts. Because the seat eliminates rhythmic pounding while the truck is in motion over a long period, it reduces the tendency of drivers to fall asleep at the wheel.

3 HOUR LATHE JOB DONE IN 1 HOUR ON DoALL



To bore 12" diam. holes in a 30" plate 1½" thick required only 1 hour each on the DoALL. A lathe could not swing the 30" plate, which had to be cut into two 15" plates and then it took 3 hours to bore each hole.







FASTEST METAL CUTTING METHOD TODAY

Whether it's armor plate, blocks a foot thick, tubing or stacked sheets, the DoALL goes right through them with no lost motion, time or energy. No other equipment or machine can compare with the DoALL for straight line and contour work, internal and external sawing of metals, alloys, plastics, laminates and wood.
6 models to select from — a size for every need — priced from $1,000 to $5,000 with motors.



Send for an interesting story-in-pictures of DoALL ADVANTAGES over 9 Basic Cutting Methods



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FARM WASTES

Provide Extensive Source Of Industrial Cellulose

CORNCOBS and other farm wastes are being converted into sugars by a continuous process which makes use of the special chemical and physical properties of the farm wastes or residues. Chemistry is transforming such waste into money for the farmer and into a rich "bank" of cellulose reserve against the day when many natural and irreplaceable national resources are depleted.

J. W. Dunning and E. C. Lathrop explain the process in "Industrial and Engineering Chemistry," American Chemical Society publication.

"It is estimated," they point out, "that 100,000,000 tons of farm residues might be available in this country for industrial purposes each year, with an equal amount left on the farms for plowing back into the soil. In view of the decrease in irreplaceable natural resources, it is becoming clear that at some period all countries must look to products of annual plant growth for the production of many materials now derived from other sources."

The Department of Agriculture, they continued, is seeking means of using such residues not mainly as substitutes but rather as raw materials that can do industrial duty better than other raw materials.

The bulkiness of most farm wastes, their higher content of pentosans—a complex carbohydrate—and lower cellulose content as compared with woods heretofore have prevented considering them as a source of raw material for sugars, the report said.

The researchers reasoned that what might be needed in utilization of farm wastes for sugars is some "added ingredient" which would be produced

concurrently and command a higher price than fermentable sugars.

This might be furfural, now manufactured to the extent of about 20,000 tons a year, or xylose (a sugar) which has potential uses if priced near sucrose. Both of these chemicals are derived from pentosans which generally occur in higher amounts in agricultural residues than in wood.

Working with corncobs, sugar-cane bagasse, flax shives, oat hulls, and cottonseed hulls, the chemists developed a continuous, two-stage process in which the pentosans in the wastes first are hydrolyzed or decomposed by dilute sulfuric acid. Then the cellulose is turned to sugar by a new concentrated acid method which uses less than one fourth the amount of acid required by other known concentrated acid processes. Lignin remains as an insoluble residue.

PLASTICS COAT

Protects Spark Plugs Until Used

ETHYL cellulose, which forms a tough, water-proof, corrosive-resistant coating that can be quickly and easily removed by slitting and stripping from the part, is now being used to protect spark plugs after manufacture and until put into service.

The conveyor used for this work is shown in the accompanying photograph. An operator hangs six plugs on each cross bar. After being immersed in the dip compartment of the Youngstown Miller Company's plastics coater, the plugs are returned overhead to the end from which they start. This system permits the uniform dipping of 4500 plugs an hour.

Indirect heat is employed to melt 100 pounds of the plastics per hour without danger of breaking down the ethyl cellulose by excess heating. Thermostatic control is maintained over both the heat exchange medium and the plastics to insure that neither rises over its maximum allowable temperature. The plastics is melted and preheated to proper temperature for dipping before entering the dip tank section of the unit. Extremely close control (2 degrees, Fahrenheit, maximum variation) and uniformity of temperature is achieved with low heating surface temperature.

GASOLINE SYNTHESIS

From Natural Gas Put On Commercial Basis

PRODUCTION of gasoline with a clear octane number of 75 motor (83 research) from natural gas for about five cents per gallon, bringing gasoline synthesis from natural gas definitely within the range of successful commercial operation by the American refining industry, is said to be possible through recent improvements of the Fischer-Tropsch process. The new process is equally adaptable to the economical production of high-cetane Diesel oil.

The five cent cost is based on natural gas at five cents per thousand cubic feet and a plant depreciation rate of 10 percent per year. The gasoline produced can be easily leaded for post-war consumption.

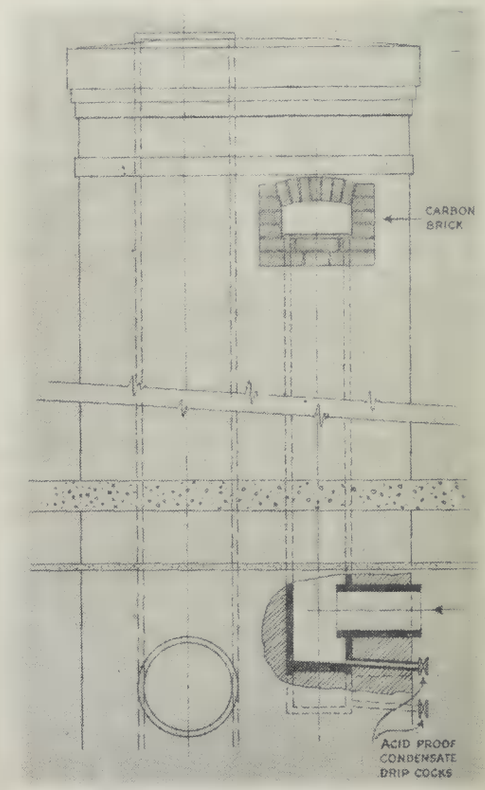
Based on technical exploratory and development work in the M. W. Kellogg Company laboratories in Jersey City, the new method successfully overcomes the problems of heat dissipation and accurate temperature control.

CARBON CHIMNEY PIPES

Prevent Seepage of Noxious Gases

CONSTRUCTION of a new laboratory for the St. Lawrence Alloys and Metals, Ltd., required that gases from furnaces and testing tables in the basement be dissipated through a brick chimney running up through the center of the building. Due to the corrosive action of the gases on the chimney brick, it was felt that periodic and expensive repair jobs would be required if the gases were exhausted directly through a chimney of the customary brick design. Also, if indiscriminately released, the noxious gases would have constituted an explosion hazard, as they contained ammonia, ether fumes, ethyl acetate, chlorine fumes, and hydrochloric, sulfuric, hydrofluoric, nitric, and perchloric acids. Not least of the considerations was the desire to eliminate seepage of fumes into the building which could result from disintegration of the ordinary brick.

Utilizing the well-known principle that carbon is resistant to corrosive fluids and gases, two eight-inch flues of carbon pipe were built into the chimney to carry the gases and protect



Flue construction for safe disposal of corrosive gases from laboratory

the brickwork. Two flues were constructed to keep separate those gases that might produce an explosion if permitted to mix. Metal hoods mounted over the testing tables and furnaces and connected to the horizontal carbon tubes carry ammonia, hydrochloric acid, ether, and ethyl acetate gases into one flue. Hydrofluoric, sulfuric, nitric, perchloric acid gases, and chlorine fumes are directed into the other.

The gases are exhausted through the flues by mechanical means. To minimize condensation, and a liquid back-drip of acid solutions that might be caused by rain or snowfall in the flue openings at the top of the chimney, roofed chambers with side outlets were built of carbon brick. The bottom of each flue consists of a slanted carbon disk covered with a built-up layer of carbon cement.

If there should be condensation and the formation of acid solutions in the bottom of the flues, the solutions will flow out through a small carbon pipe spillway located directly under the inlet section, when the carbon dripcock is opened.

Each of the carbon flues is 31 feet in height and is formed of threaded lengths of carbon pipe. Joints are sealed with a carbonaceous cement with the



Dipping compartment for spark-plug protection is in center

female threads in the upward position, thus providing an added protection against seepage. According to reports released by the St. Lawrence company, the exhaust system is highly efficient, and the gas fumes originating in the laboratory are undetectable on the floors above. Carbon material for the flues were supplied by the National Carbon Company, Inc. Its engineers believe that the flues should remain in maintenance-free service for a minimum of 30 years.

FILTRATION UNITS

Make Chemical Equivalent of Distilled Water

ORDINARY water can now be transformed into the chemical equivalent of distilled water by a simple filtration process made available in portable and stationary equipment designed for all types of users. With these units, trademarked Filt-R-Stil, water which is virtually mineral-free is made readily accessible for research laboratories and industrial use. The principle utilized is one of filtration by skilful utilization of melamine-derived and other resins, developed by the American Cyanamid Company. Water is passed through beds of these ion exchange resins which transform the dissolved salts in the water to the corresponding acids and in turn absorb the acids. The process may be visualized by picturing water as containing flowing metals which are attracted by a magnet except that the magnet, in this case, is chemical rather than electrical.

The final demineralized water has an average salts content as low as two parts per million of calcium carbonate, and has been produced as pure as one-half part per million. The process also removes dissolved carbon dioxide from the water, a feature of particular importance in its use in the electronic and electrical fields.

ALUMINUM ALLOY

In Oil Breather Caps Cuts Service Charges

SUBSTITUTION of a combination of aluminum alloy wire crimp in engine oil breather caps has eliminated a service problem on buses and trucks, has effected a saving of critical copper, and has reduced excessive oil consumption.

The new material is composed of 96 percent aluminum and 4 percent magnesium wire. It originally was adopted as a war-time expedient to replace hard-to-get copper crimp. But results have been so satisfactory that it will be retained when peace-time production is resumed.

The prime advantage of the aluminum alloy crimp, developed by Ford engineers, is that it does not promote varnish, whereas copper actively helps this formation because copper acts as a catalyst and accelerates the formation of injurious gum deposits in the oil itself.

Heavy varnish deposits on oil breather packing accumulate rapidly on buses and trucks because of their higher operating temperatures. Thus, servicing is made more difficult, due to cap sticking, while excessive oil consumption may result from increased internal pressure forcing the oil past the rings or retainers.

ELECTRONIC OSCILLOGRAPH

Records Extremely Short Electrical Phenomena

A SELF-CONTAINED industrial electronic oscillograph capable of recording characteristics of electrical phenomena lasting as little as a fraction of a millionth of a second is announced by Westinghouse.

An instrument of the cold cathode type, the electronic oscillograph is capable of recording single electrical transients with respect to time, or two electrical phenomena with respect to each other, such as voltage versus current, in the form of diagrams produced by two pairs of electrostatic deflecting plates disposed at right angles to one another. The cathode of the tube is energized from a 50 kilovolt D.C. rectifier with a control to correct for line voltage variation. The beam is normally blocked by a target. An impulse synchronized with the phenomena will trip the relay which bends the beam around the target so that it will strike the fluorescent screen or film placed below it and thus be rendered visible or recorded.

The new streamlined unit consists of the oscillograph proper in front of the cabinet and the cabinet proper which



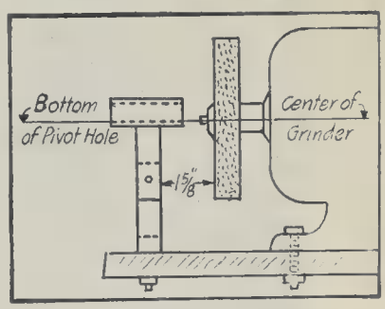
New Quick-set Dial Drill Sharpener Eliminates Guesswork...Keeps 'em Drilling Faster—Longer

Attached to the Drill Sharpener, it adjusts drill edges to the proper angle for precision grinding, putting drill sharpening on a quick, efficient basis.

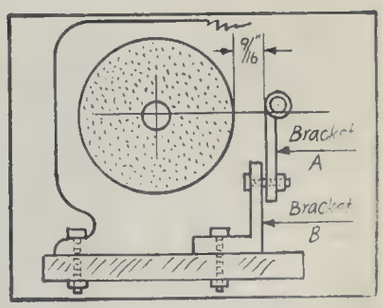
QUICK-SET DIAL easily and accurately adjusts Sharpener for sharpening drill from 5/32″ to 1″ sizes. Dial insures accuracy in measuring angles and clearances on twist drills, preventing trouble and making drills last longer. Dial-Set sharpened drills cut faster and more accurately, as the edges are alike and uniformly sharpened.

Precision built, calibrated and tested, unit is easy to set up and operate. Saves wear and tear on drill presses—prolongs drill life—cuts costs—improves quality—speeds output.

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Front view of grinder



Side view of grinder

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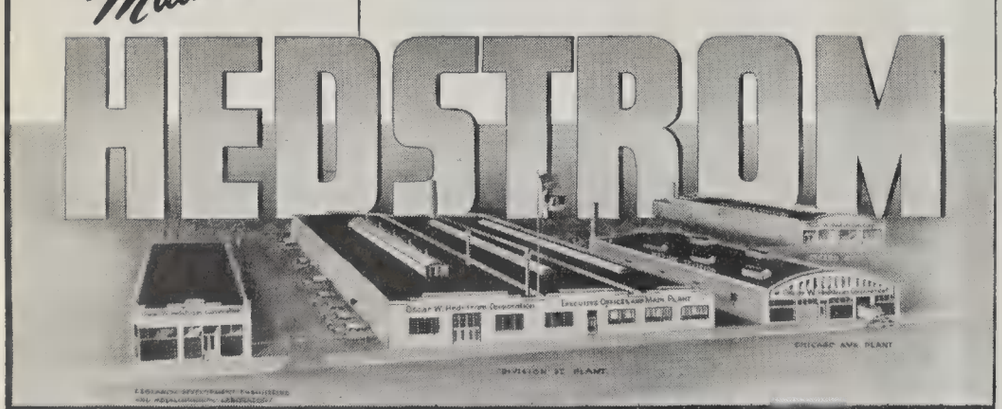
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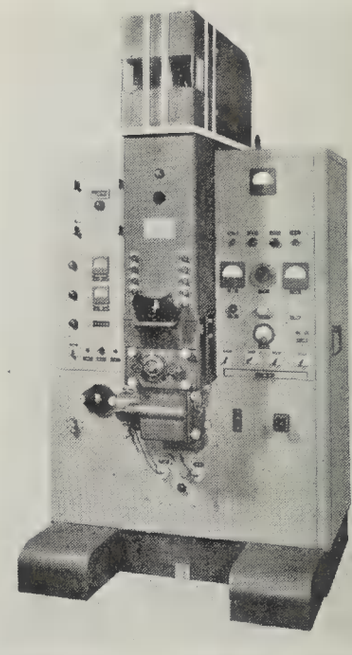
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ELECTRICAL STABILIZER

May be Used Post-War On Many Vehicles

THE post-war automobile and train ride may be easier because of an intricate device called the gyro-stabilizer, now being used for accurate aiming of high-powered guns on battle tanks as the machines move over rough terrain.

Electrical manufacturers say this is the way the gyro-stabilizer works on United States tanks:

"A piston in a cylinder attached to the breech of the tank's gun moves up and down to stabilize the gun's movement. The piston is moved by oil under 200 pounds pressure, fed from a gear pump. The amount of oil fed to either side of the piston is controlled by two magnetic waves.

"A 'silverstat' varies the voltage—or electrical pressure—flowing to the valves and consequently the oil flow to the cylinder. A gyroscope is attached to the breech of the gun where its rotational direction is subject to violent change every time the tank rolls over a stone or pitches into a ditch.

"At the first sign of jolting of the gun, the gyro complies with the law governing its nature; in resisting the downward or upward jerk of the gun barrel, its own axle rotates at right angles to the up or down movement, and in effect 'waggles' the gyro.

"With each waggle to right or left, a pencil-thick stub of plastics attached to the gyro and centered in the cluster of silverstat leaves squeezes together one or the other group. This increases or decreases the voltage, and consequently the current, which flows to—and activates—the magnetic oil valves."

It sounds a little complicated, the electrical experts admit—but it may add up to a downy-soft post-war ride, even over bumpy rural roads in a car, or over rough roadbeds in a train.

SHRINKAGE CONTROL

Applied to Woolens by Use of New Resin

WOOL, which retains its original appearance, yet is protected against shrinkage, even after repeated laundering and dry-cleaning, is now commercially available through the use of a new synthetic resin manufactured by American Cyanamid Company and trade marked under the name "Lanaset."

Lanaset, a melamine resin, has already been tested with success by a number of leading mills and finishers. Lanaset wool shrinkage control has also been used by the United States Army



Two hours in soap and water did not change the sock treated with Lanaset

Quartermaster Corps for treating, among other items, three quarters of a million yards of wool sleeping-bag fabric.

Lanaset stabilizes wool and wool blends without affecting the absorbency normally characteristic of wool. The usual chemical methods for controlling shrinkage actually alter the wool and destroy some of its valuable properties. Lanaset, on the contrary, is an additive and takes away none of these desirable qualities. It also reduces felting and prevents fuzzing. Wool treated with Lanaset has a much higher resistance to alkali than untreated wool.

Another advantage of Lanaset, according to reports, is the simplicity of its application. The fabric is passed through an aqueous bath containing the resin, squeezed uniformly through a mangle, dried and heat cured, and given a light wash to remove surface resins. The application is permanent for the life of the fabric.

This stabilizing finish for wool fabrics is expected to be of particular value in the processing of dress materials, blends of wool and spun rayon for sports wear, tropical worsteds for men's suits, sweaters, children's wear, blankets, and socks.

COPPER ON ALUMINUM

Made Practical by New Preparatory Dip

ADHERENT, uniform copper plating is now made possible on aluminum and its alloys by a preparatory dip at room temperature. The dipping solution may be used in a steel, wood, or ceramic container. There are no fumes, it is said, and venting is not required. This solution has a long life, is stable, and is not sensitive to drag-out, normal contamination, or dilution.

Practically any copper electrolyte can be used as the plating solution except the sulfate types or those having a high degree of acidity. High-speed, bright-copper can be deposited with ease.

Copper plating on aluminum brings greater utility to this light metal. Aluminum is difficult to solder, but a flash coat of copper eliminates this trouble. Aluminum also has a strong tendency to develop an oxide coat on exposure to air. While aluminum itself is a good electrical conductor, this oxide coat reduces conductivity considerably. When aluminum is copper plated, this difficulty is overcome and the light metal becomes useful for electrical contacts and high frequency conductors where weight is a factor to be considered.

When aluminum is copper plated and polished, it eliminates the usual dull aluminum finish. Also, copper plated aluminum can be used to build up worn surfaces, over-sized diameters,

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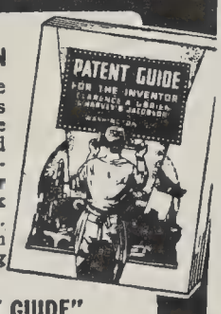
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A new type of centrifugal pump, based on the ejector principle, has been designed so that each pump with its fittings may be used in both shallow and deep wells.

When in operation in a shallow well,

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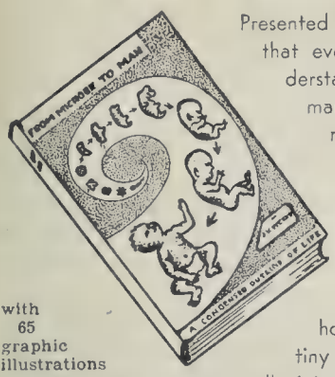


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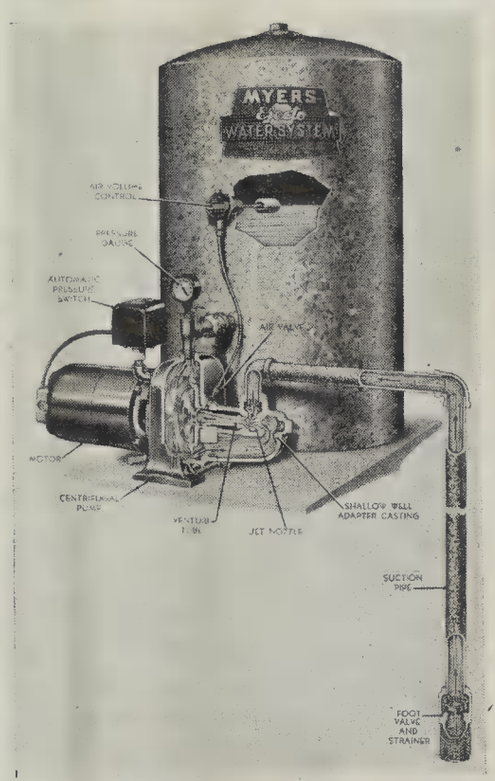
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part of the water circulated in the pump case by the centrifugal impeller is diverted to the nozzle. Water passes through the nozzle at high velocity into the venturi tube, creating a partial vacuum, causing water to be drawn from the well and from the ejector nozzle. Passage through the venturi tube converts velocity into useful pressure. The effect of the ejector nozzle and venturi tube is to increase both suction lift and discharge pressure.

For operation in a deep well where the water must be lifted more than 28 feet, the shallow well ejector unit is removed from the pump case. A pressure pipe is then connected to the lower opening in the pump case and the delivery pipe fitted directly to the impeller opening. The two pipes are inserted side by side to a proper depth below water level where they are connected with the deep well ejector unit containing a jet nozzle and venturi tube. This, when needed, may be purchased separately. Manufactured by the F. E. Myers and Brother Company, under the trade name of Ejecto, the pump is



This picture shows the shallow well ejector bolted to the pump case. It increases suction lift and pressure

driven by a standard type electric motor of dual voltage and with overload protection.

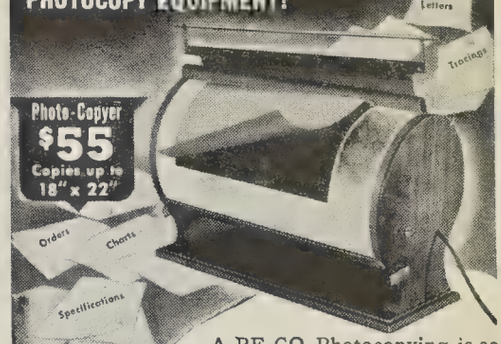
The capacity of the new pump for use in both deep or shallow wells is an advantage in the event of the water receding in the same well, or if the owner wishes to shift over from one kind of well to the other.

POLYTHENE INSULATION

Seen Widely Used When War Ends

POLYTHENE PLASTICS may be used for insulating undersea electrical cable after the war. The material is reported to be fungus-resistant and it is not attacked by salt water, a Du Pont expert says, explaining its advantages

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Much has been written about the wise men of old. A popular fallacy has it that their secrets of personal power and successful living were lost to the world. Knowledge of nature's laws, accumulated through the ages, is never lost. At times the great truths possessed by the sages were hidden from unscrupulous men in high places, but never destroyed.

Why Were Their Secrets Closely Guarded?

Only recently, as time is measured; not more than twenty generations ago, less than 1/100th of 1% of the earth's people were thought capable of receiving basic knowledge about the laws of life, for it is an elementary truism that knowledge is power and that power cannot be entrusted to the ignorant and the unworthy.

Wisdom is not readily attainable by the general public; nor recognized when right within reach. The average person absorbs a multitude of details about things, but goes through life without ever knowing where and how to acquire mastery of the fundamentals of the inner mind—that mysterious silent something which "whispers" to you from within.

Fundamental Laws of Nature

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at a symposium on polythene insulation and radio-frequency cables. Its use as an insulation on submarine cable, and in other applications where contact with salt water has deleterious effects on other materials, is being investigated. Protective coatings for metal parts which corrode in salt water also are being studied.

"Polythene has very largely replaced all other materials in the insulation of military wires for high-frequency use," the speaker said. "After the war it is expected that the use of polythene in electrical equipment will continue and expand, and that further varieties and modifications of it will be developed to meet specific needs."

Once the material becomes available in quantity for civilian uses, there will be many fields of application in which its unusual combination of properties will make it valuable. Its good resistance to chemicals points to its utility in chemical equipment as a coating and gasketing material, while its impermeability to moisture indicates a broad utility in containers and the packaging of foods. In this field it may be used as sheeting, as molding powder, or as an impregnant or coating of paper.

RADIANT HEAT

Keeps Outdoor Pavements Free from Snow

RADIANT heating, already functioning in many indoor installations, is now being brought out-of-doors to put an end to shoveling snow or chopping ice from walks and drive-ways. Such outdoor installations have been made at factory plants, one at Bethlehem, Pennsylvania, and the other at Buffalo, N. Y. Designers of some post-war filling stations also have incorporated similar use of radiant heating in drive-ways leading to gas pumps.

At the Bethlehem factory, employes had to walk out of doors a considerable distance from the main plant to the cafeteria. Since it was not feasible to erect a covered walk-way, a concrete footpath was installed, with wrought-iron heating coils installed beneath. A



Steam pipes under the pavement melt snow before it can block the yard



Installing wrought-iron pipe coils for melting the snow by radiant heat

snow- and ice-free walk resulted. Hot water is circulated through the 1¼ inch pipes, for melting the snow which falls on the footpath, or to prevent the formation of ice during a freezing rainstorm.

In the Buffalo installation, low-pressure steam from the plant's boiler is fed into similar size wrought-iron pipe coils whenever it is necessary to melt and remove snow from the loading strip in the plant's yard, before the fall has had a chance to pile up. The installation is 80 feet long and 8 feet wide.

Because of its ease of fabrication, its weldability, its resistance to underground corrosion, and its high heat emissivity, wrought-iron pipe is used in both installations.

COOLER TIRES

Made Possible by Process Utilizing Epsom Salts

MAGNESIUM sulphate, sold in thousands of drug stores under the less technical name of epsom salts, is the key material used in a new rubber compounding process developed to reduce the heat failure of heavy-duty synthetic rubber tires. Chemical engineers have long known that the addition of zinc oxide would make tires cooler running, but no method had been found to mix properly enough zinc oxide with the rubber.

Firestone engineers developed the magnesium sulphate process to solve this difficulty, and now equal parts of synthetic rubber latex and zinc oxide can be mixed together and coagulated easily and quickly. Sufficient quantities of the new rubber have been produced for large-scale development and road-testing work.

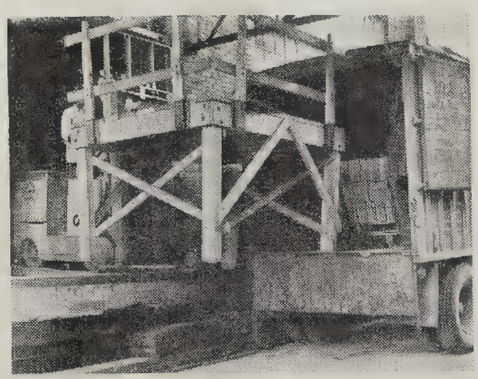
PORTABLE PLATFORM

Solves a Factory Unloading Problem

THE problem of unloading motor trucks on a narrow and congested street has been neatly solved by R. J. Reynolds Tobacco Company. When incoming loads were backed up at right angles to the receiving room door they blocked traffic badly and were a possible source of nuisance accidents. The Reynolds plan made it possible for the delivery truck to park lengthwise of the street for unloading, by building a rugged yet portable loading and unloading platform, which can be kept inside the building and out of the way when not in use.

When a loaded truck arrives at the plant the driver parks near the entrance, close to the wall, and lowers the tailgate. Then an Elwell-Parker fork-type power truck picks up the portable platform and spots it on the pavement so that it provides a continuous runway from the floor of the truck to the floor of the receiving room.

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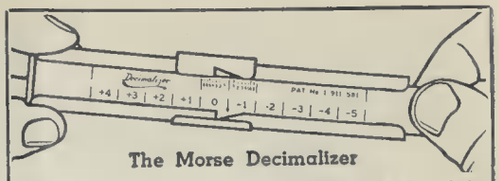
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chlorine dioxide to remove taste and odor caused by phenolic waste. The chlorine dioxide is generated by dispensing a sodium chlorite solution into the discharge line of a Wallace and Tiernan chlorinator. A constant dosage of 0.5 parts per million available chlorine is maintained, which, it is claimed, is sufficient to remove all taste in a severely contaminated water.

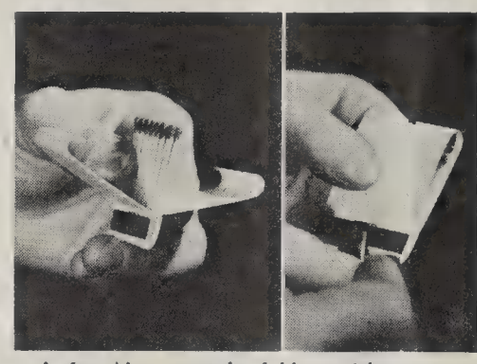
Following experiments with the process on a laboratory scale, plant-scale operations were carried on at an auxiliary filter plant of the City of Niagara Falls Water Department. This plant, which supplies three to eight million gallons of water per day, has an "on-shore" intake which often became so contaminated with phenolic compounds, according to Dr. Vincent, that the customary method of treatment was inadequate. Variations in the degree of contamination aggravated the problem.

Three months of operation with the chlorine dioxide process demonstrated that it destroys phenolic taste and odor permanently and completely, Dr. Vincent stated. Additional advantages claimed for the process are considerably reduced chemical costs and simplified plant operations. The process is now used for purification of the entire Niagara Falls water supply.

SAFETY MATCH

Cover Must Be Closed Before Striking

INTERESTING is the mechanical construction of a new safety match "card" recently developed by Mr. Giuseppe Russo. The cover is in one



Left: New match folder with cover open. Right: The cover locks closed

piece, but both sides are hinged at the bottom as shown in the illustrations. The top edges are turned in an arc and crimped with heat and pressure so that they retain their shape. As the cover is closed after removing a match, the natural movement of the fingers holding the case causes the curved sections to snap into a locked position. Thus it is almost impossible for anyone to strike a match with the cover open—an obvious safety feature in view of the number of accidents that have occurred with conventional match cards.

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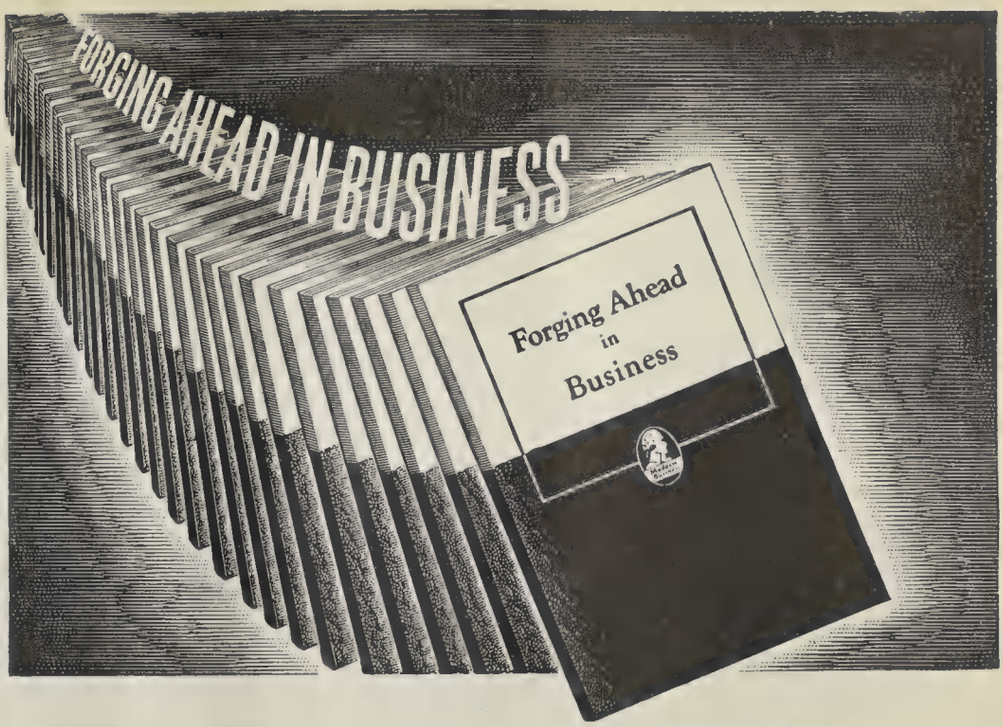
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SOME PROBLEMS INFLUENCING THE DRAWING OF FINE WIRE, by H. P. Edinga, is an eight-page folder describing the industrial importance of fine wire and discussing its drawing problems. The relationship of die wear to length of wire drawn is pointed out in chart form. *North American Philips Company, Inc., Publicity Department, 100 East 42nd Street, New York 17, New York.—Gratis.*

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

THE FOLLOWING is a continuation of the article on making objective lenses without recourse to an optical flat, begun last month by Patrick A. Driscoll, of Rochester, N. Y.

So far we have tested only for radius of curvature. In testing for figure or irregularities we revert to the small pinhole and we may use the edge of the frosted glass as the knife-edge.

When the test plate has been polished to a curvature of —935.51 and corrected for irregularities (we want the even gray shadow of the sphere) we turn it over and on a new polisher proceed exactly as before to polish the —2884.64 curve. This will not in any way affect the figure of the first side.

The —666.46 curve of the flint glass will be our next surface to polish. Since this surface is to be used not only as a temporary test plate, but is also our flint component, it then follows that it must be polished completely, leaving no pits. A scratch on any of the surfaces should be ignored, as the time expended to regrind or polish it out is not worth the infinitesimal amount of light lost in transmission.

TEST PLATE READING—Having all our minus curves polished, we are now ready to polish the plus curves, and now at last comes the application of test plates. We shall start to polish the back side of our flint component (the +2884.64 side). As soon as we have a reasonable polish on it we are ready to test, and we must now enter into a short study of the behavior of interference fringes, or Newton's rings. We place the —2884.64 side of the test plate on the flint lens and, using a sodium light ("A.T.M.," page 244), if we have ground tightly to our gage, and if we have entirely freed both surfaces from dirt or lint which would prevent the ring pattern from forming, we shall immediately see the rings.

We place the thumb and forefinger of each hand on the edge of the test plate, making a roughly four-cornered application of pressure, and press lightly. The rings, under pressure, will appear to well up, or roll into the center of the lens. If the rings well up out of the center and roll to the edge, the lens is "high," too convex, or overcorrected. If, under pressure, they roll in toward the center and seem to disappear down into the center, then the lens is "low," too concave, or undercorrected. The simple and easily remembered rule of test plates can be memorized by this mnemonic: "Since high is *up* and low is *down,* then it follows: if the rings come up the lens is too high, if the rings go down the lens is too low."

If the lens is high, or too convex, we must polish the center more than the edge. If low or too concave we must polish the edge more than the center.

On this job all surfaces are permitted to be as much as five rings higher or lower than the test plate that fits them. This will give us a ten-ring range for smoothing out irregularities. For every ring (consisting of one bright band plus one dark band) we are 1/100,000" away from our test plate curve.

If the rings are even and concentric, then the lens also will be spherical and have no zones.

If, under Foucault's test, the test plate showed no zones, then any zones that show in the rings will be on the lens surface we are testing.

Now for the contour test, or using the test plate to show what the surface is by an actual picture. It is not necessary to know this method but it will help the worker in understanding how his test actually looks. We place the test plate on the lens and, when the rings have appeared, apply pressure with one finger on one side of the lens at the edge. The rings appear to roll either toward or away from the point of pressure. They roll apparently right off the edge of the lens and then leave curved bands (Figure 3).

If the rings roll away from the point of pressure they will show such a series of bands as in 1; if toward the point of pressure they will show a pattern such as in 2.

If we regard the drawings as round, framed pictures and the point of pressure as its bottom, then 1 is a picture of a lens that is too low and 2 a picture of a lens that is too high.

Again, 3 is a lens that is high, with a hole or low zone in the center, and 4 a lens that is low, with a still lower hole or zone in the center.

CENTERING— When the lenses or components have all been polished and show approximately five or less concentric rings above or below the test plate (ignore turned edge if not over 1/8" wide, as the cell mounting will hide it), we are ready to center or true them up and bring them to equal diameter. I believe that a centering spindle should be vertical, to minimize chance of the lens falling off while its optical axis is being lined up to make it run true with the axis of the spindle. The flint lens will be centered first, as the possibilities of developing prism or "wedge" in it are much greater than in the crown. Unless our measurements around the edges of the components, to eliminate wedge in grinding, were very lax, the crown will be so close that it will unquestionably center down to the flint; whereas the flint usually loses more in centering, due to the long radius of curvature of its back.

The spindle may be anything that ingenuity may devise. Figure 4 gives an idea of one such setup. The target used in alining the optical axis of the lens may be an ordinary flashlight with a "T" cut in a black paper mask placed over its end. Spindle speed should be about 250 rpm. The target should be about 2' above the spindle.

The flint lens is mounted on the spindle in the following manner: Take it upstairs to the kitchen and, over the little woman's or girl friend's protests, place it in the cold oven. With the gas turned low bring it *slowly* to a temperature that could be called "good and warm"—say, 140 degrees. Fahrenheit.

Next, heat the spindle with a bunsen burner, smear ordinary sealing wax around its edge, and place the warm lens on it. Rotate it slowly and note the reflections of the target light. There will be two, one from each surface of the lens, and these reflections will appear to rotate as long as the optical axis of the lens remains eccentric with the axis of the spindle. Revolve the spindle and move the lens this way and that (warming the spindle occasionally with the burner to keep the wax soft) until the reflections are stationary. Now the respective optical axes coincide but, unless the lens edge was ground more uniformly to thickness all around than is likely in spite of care, the lens itself is off center and must be centered. The actual centering is accomplished by applying slow abrasive pressure on the lens edge, by means of a brass band controlled by a turnbuckle.

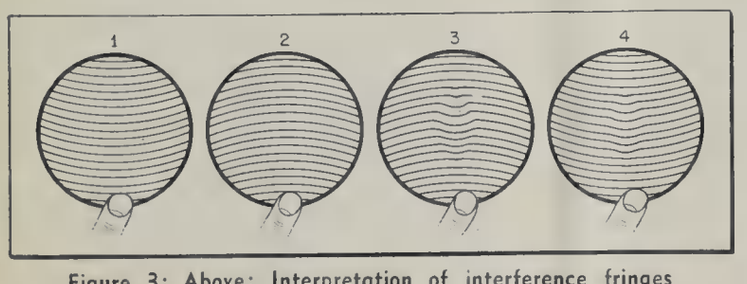


Figure 3: Above: Interpretation of interference fringes

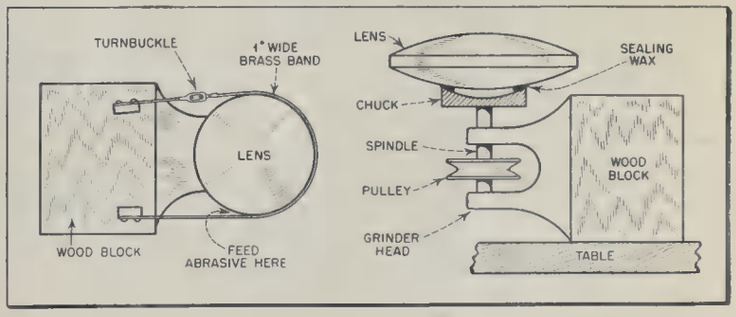


Figure 4: Right: A simple spindle for centering lenses

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using No. 180 emery or Carborundum. If you prefer a smoother finish, give the edge about two minutes additional of No. 500.

Stop the centering of the flint as soon as the edge shows no flat spots. Stop the crown as soon as the diameter of the flint lens is reached. The remainder of the excess diameter can be taken up by the cell mounting, as this lens is calculated to give the very best results with a finished diameter close to 4⅞". It is unnecessary to grind off excess diameter. Removing glass that can do no harm to the objective's ultimate performance can be a long and tedious process.

CEMENTING—Procure from your druggist a piece of pure Canada balsam and a half pint of alcohol. Place both lenses in the *cold* oven and warm them *slowly* to a point at which the balsam, under trial, will melt instantly upon application. This will be very hot, since we do not want the balsam to be merely glue-like; *it must be liquid.*

Remove the flint lens from the oven, place it on a clean paper and apply about one half teaspoonful of melted balsam to the center of the concave.

Now, using gloves, remove the crown lens from the oven and place it straight down on the flint. *Do not slide it.* Press down with considerable pressure. The balsam in the center will spread evenly out to the edge and the excess will run down on the paper. Pressure on one side or the other will persuade bubbles to disperse to the edges and disappear.

The crux of the operation is heat and lots of it *but do not hurry it;* apply it slowly. A good way to keep the lenses hot while eliminating trapped air bubbles is to rest them on the flat, level face of an inverted and braced electric flatiron.

Clamp the achromat around the edge with a simple metal band to keep the lenses from shifting off-side and let it cool until cold—naturally, not assisted, since to hurry the cooling is to ask for a cracked lens.

When it is cold, remove the band and clean the excess balsam from the edge with alcohol and, behold, you are now the proud possessor of a perfect telescope objective!

ANOTHER DESIGN—I chose the specifications named because I have produced this achromat and found it gave excellent results on all tests for all aberrations, with a minimum of secondary spectrum. As an alternative I submit specifications for a smaller but equally good lens for the amateur who does not wish to tackle a larger achromat as a first attempt.

Diameter 95 mm, a little over 3⅝".
Focal length 1226 mm.
Focal ratio 12.9.
Blank sizes: each 15mm thick, 100 mm diameter, Bausch and Lomb.

Crown: C—2 1.5125 60.5
Flint: EDG—2 1.6890 30.9
r_1 +750.00 mm
r_2 +545.29 mm
r_3 −545.29 mm
r_4 +1503.81 mm
t_1 14 mm
t_2 12 mm

May I wish the amateur success in this undertaking. I shall be glad to answer any questions regarding these instructions.—*P.A.D.*

NO READER need be left wondering whether Driscoll claims to have originated the above-described testplate method (sometimes it is called proofplating). Fearing this might happen, he asks that its true antecedents be made as plain as day. This basic method of reproducing lenses was used long ago by Zeiss and others. It is described in Dévé "Optical Workshop Principles," also in Twyman's "Prism and Lens Making"—not, however, with added instructions for making objective lenses. Driscoll's true contribution to fellow amateurs consists essentially—in addition to the valuable specifications for two achromatic objectives which he donates—in the preparation and offering for publication of a rounded, organized, systematic sequence of operations for making objective lenses for refracting telescopes by amateurs, employing the testplate method as its most characteristic part. Nor has anybody actually published such a procedure for that specific method, so far as is known. (But it does the public no practical good to be told by someone in a commercial industry, after a given method has been published, that it has previously been in use in a given shop, if no one in that industry has ever bothered to make it available to all.

When Driscoll's manuscript was received, it was shown to Dr. D. Everett Taylor, 191 Prospect St., Willimantic, Conn., author of a chapter on the refractor in "A.T.M.A." He took an immediate interest in it and, with a copy of the manuscript constantly at hand, made a 4" objective lens strictly according to the steps of the testplate procedure. His comment while making it was: "The Ronchi bands, which permit of being reduced to one in number, thus revealing almost maximum distortion, are straight." At the completion of the job he wrote: "Shop and indoor testing of the unmounted lens for star image and definition give this method a high rating. It offers every opportunity for the most precise craftsmanship, since at all times one can know the exact condition of the surfaces. It eliminates two big items: iron tools (difficult to machine accurately) and an optical flat. In short, after following it through, I would switch to Driscoll's procedure if tomorrow I were to start the most important objective of my experience."

FURTHER notes on the Driscoll procedure will follow next month, including details of a method of reducing the size of the objectives he has specified, if this is desired.

OPTICAL glass specified in these articles cannot yet be had—needed for war. Have to wait a little.

NEWS note: Thus far two Maksutov telescopes have almost been completed, out of the 19 entrants. Most of the 19 are doing war work, which comes first. Have to wait a little here.

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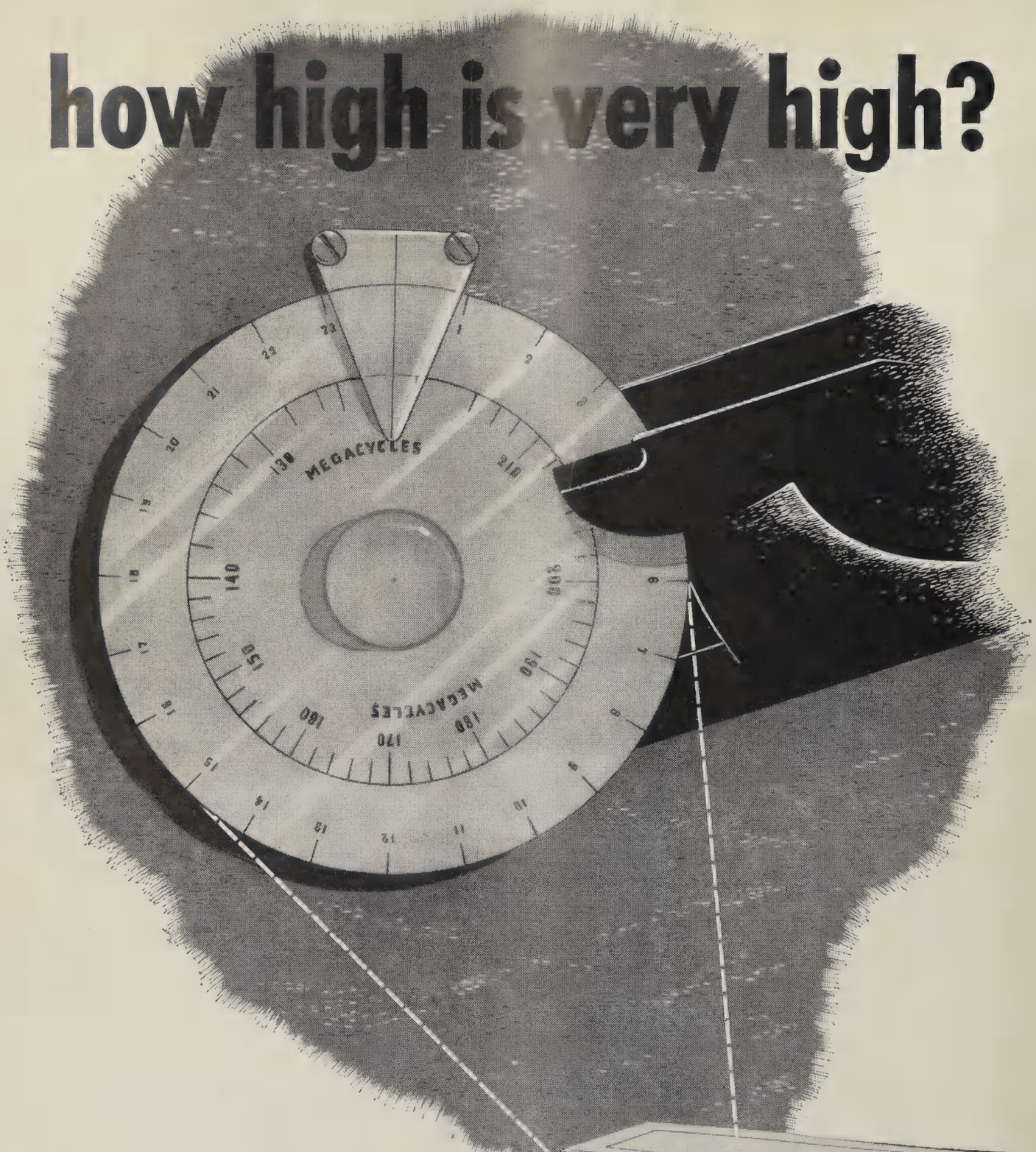
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WANTED

Ideas and Inventions For Postwar Products

Automatic Electric Company, originator of the dial telephone and leading manufacturer in the field of communications and electrical remote control, seeks to make contacts with inventors and others who may have patentable ideas or inventions for sale or license. Objective is the acquisition of newly invented or improved products that have peacetime application, which will make use of the company's expanded productive capacity, and which will help to maintain employment for its engineering, production and sales personnel during the postwar period.

Invention should relate to wire communications, point-to-point radio, electric remote control, or to mechanical, electrical or electronic devices used in such systems. Replies should be addressed to Mr. C. S. Cadwell, Vice-President. All ideas submitted will be given careful consideration and treated with the utmost confidence.

AUTOMATIC ELECTRIC COMPANY

1033 West Van Buren Street, Chicago 7, Ill.

Previews of the Industrial Horizon

By A. P. Peck

LABOR DRAFT TROUBLES

FROM England come lusty wails about the labor draft; clear and positive proof that there is no fear of any such thing surviving the war and that the United States would be better off to stick to the volunteer system.

The British law applies to all males and females from 18 to 51 years old. One hundred percent of the available males, 86 percent of the unmarried females, and 30 percent of the married women have been inducted into war work of some kind or have voluntarily "joined up."

England believes that she could not have kept up her war work without labor conscription. But she takes the law as she might swallow some strong and toxic sulfa drug, willing to endure the shivers and headaches in order to fend off something worse.

Main kick of the worker is that there is no uniform wage scale, and there cannot be unless the nation is to be completely socialized. Cases of workers being drafted into higher paid jobs are exceedingly rare since the high-wage industries attract plenty of volunteers. But cases of highly paid machinists being shipped back to the mines, textile mills, and other poverty-pay spots are frequent. Every man gets the pay which is normal for the job he is given. Superior ability means nothing and opportunity for self-improvement is curtailed.

British management has two problems under the labor draft. First, once a worker is assigned to a factory, that plant must pay him whether it has any work for him to do or not. Contract cut-backs, changes in processes and methods, none of the normal reasons for firing a man or of replacing a worker of one skill with a worker of another via the open labor market can be used until the draft board has taken its slow and ponderous action. Without this provision, of course, a man could be drafted to a plant only to be fired the next week, thus practically being drafted into unemployment. Second management agony is that labor is taking this opportunity to press for the annual guaranteed wage. Thus if the war should end suddenly, management might find itself saddled with workers which it had kept in idleness for several weeks and would have to keep for months after its own income had been shut off. The burden on reconversion costs would be unbearable.—*E.L.C.*

JACK-OF-ALL-TRADES

GLYCERINE—glycerol, as the chemists call it—is a chemical jack-of-all-trades if there ever was one. It has been used widely in medicine and industrially as a moisture-absorbing agent, as a solvent, as a lubricant, as an anti-freeze, as a blending agent, and so on. Most important of the chemical combinations entered by glycerine are the alkyd resins, indispensable in modern synthetic coating, ester gums, and nitroglycerine. But the end is not yet in sight.

The alkyd resins have given new impetus to quick-drying finishes and in the offing are water- and ice-repelling coatings, together with fabric and yarn treatments that will provide properties of heat, acid, and alkali resistance. In England, it is reported, rayon fabrics have been treated with these resins to provide a substitute for oiled silk, an essential in wound dressings.

Looking a little farther into the applications of this versatile chemical, it is found that glycerine alkyds are being used increasingly in the art of printing and dyeing of textiles and that photography has welcomed them with open arms as ingredients in color films and the new "self-developable" photographic emulsions.

The facets of glycerine seem almost innumerable. It keeps cellophane from becoming brittle and is used in manufacturing protective clothing for workers which is not affected by acids or petroleum solvents and that will guard the wearer against certain toxic gases. It is an important ingredient in materials used in electro-polishing methods and, by the ton, it enters the manufacture of many base flavors for food products, including soft drinks.

ENGINEERS AND SALES

A SALES-MANAGER who takes a realistic view of the future of America is James H. Rasmussen of The Crosley Corporation. Taking note of present incomes of war workers and the reductions in take-home pay that will come inevitably with war end, he recently gave the nod to engineers by saying that in the immediate future "our engineers will have the task of improving sharply the products which we have come to accept as necessary to our way of living. It has been said that the highest need for the future is a high degree of obsolescence for consumer goods. . . That means 'progressive obsolescence.' Products must be improved to the point where it becomes economically sound for Mr. and Mrs. America to buy the new model.

"We must sell our corporations the idea that the road ahead may be rough," he said. "We must caution them against the over-optimism that pervades our press and trade reports. . . We must sell the necessity for carrying through product improvement and new product development."

PRIME MOVERS TOMORROW

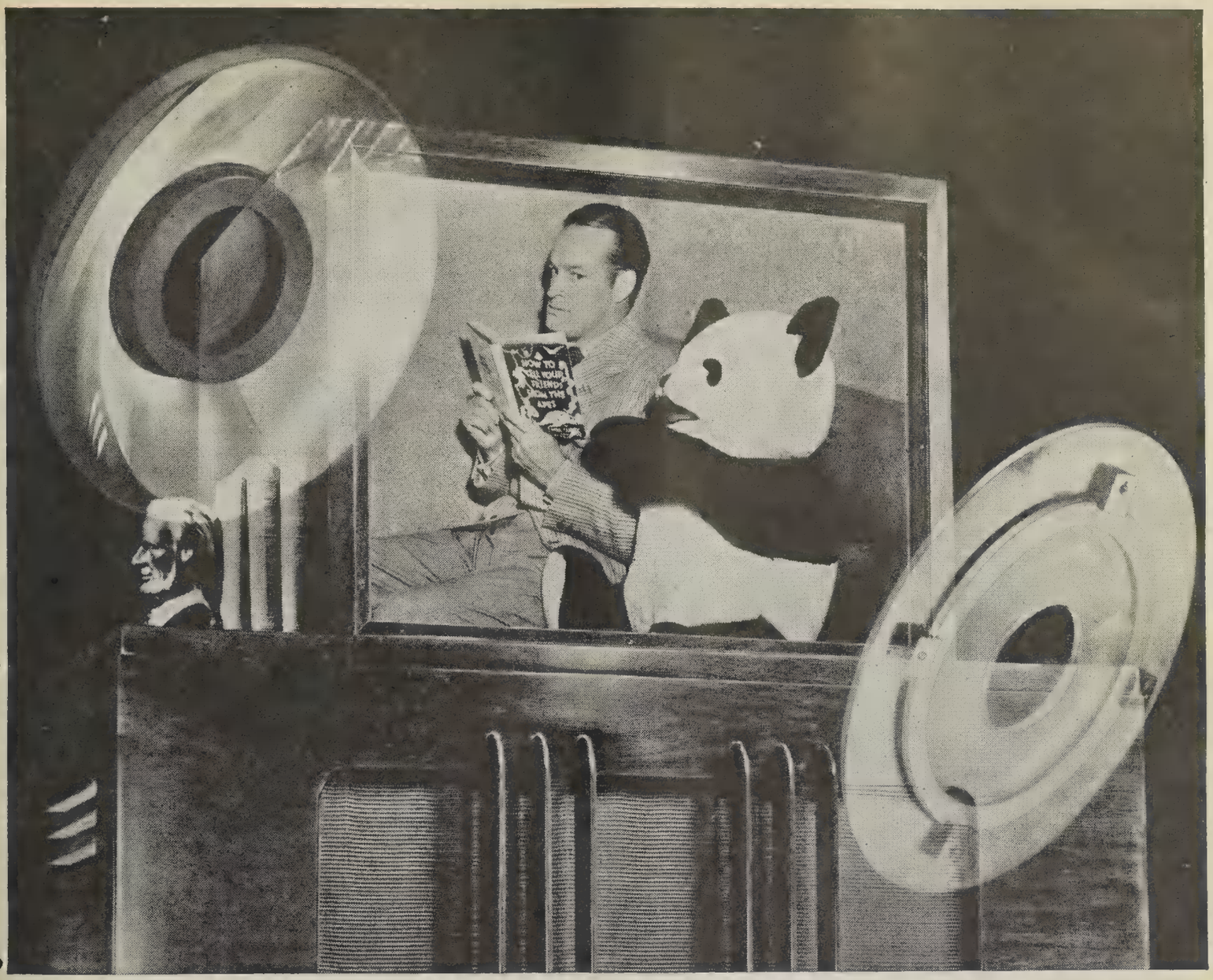
SUPERCHARGERS on bus and truck engines giving 20 percent more power per cubic inch of combustion space, improved fuels and higher compression ratios that will add another 10 to 15 percent to efficiency, automatic timing change mechanisms that will give top efficiency at all engine speeds, bearings that will withstand greatly increased pressures, and new spark-plug electrode materials that will have ten times the life of existing points are some of the developments on the horizon envisioned by forward-looking but hard-headed engineers today.

FUEL POSSIBILITIES

THAT the railroads are not satisfied with locomotive fuels today is shown by the recent start of a million-dollar research project that is aimed toward increasing the efficiency of steam locomotives, strengthening their position in competition with Diesel locomotives, and assuring a continued market for bituminous coal. The important aspect of the program is the fact that a combination of interests can achieve a far greater measure of success than can one industry alone.

FOR FUTURE REFERENCE

EVEN greater accuracy is on the horizon for machine tools. . . Magnesium is rated as a versatile material for development by small industries where weight is important. . . Air conditioning, proved pre-war as a merchandising plus in retail establishments, will assume even greater importance in the future. . . Hand-made glass-ware, long imported in the better grades, can retain its American identity gained during the war only through a strenuous effort to sell the "American style."



RCA Laboratories model with an 18 by 24-inch screen showing how Bob Hope may appear on future home television.



Dr. D. W. Epstein with a projection television tube, reflector and lens unit. Here the image on the end of the tube hits the reflector, is corrected by the lens, projected to the screen, then enlarged . . . making possible larger and clearer television than ever before.

New Projection Television - Bob Hope's face "big as life"

Can you picture Bob Hope on television . . . seeing his face *big as life*—right in your own living room?

Well, you will—for now, thanks to RCA research, all limitations on the size of home television screens have been removed.

RCA Projection Television sets can have 18 by 24-inch pictures, or for that matter, pictures as large as the screen in a "movie" theater!

When you tune in an NBC television broadcast you'll almost think the actors are in the same room with you—and trust NBC, America's No. 1 network in sound broadcasting, to bring you the best in television entertainment.

This revolutionary improvement was achieved in RCA Laboratories by development of an entirely new reflector and lens, shown in phantom above. This lens, of inexpensive plastic, is 8 times as efficient for the purpose as the finest optical lens.

When you buy an RCA radio, phonograph or television receiver—or any other RCA product—you receive the benefit of the latest research development of RCA Laboratories. It is this *plus value* which is your assurance of lasting satisfaction.

The widespread public recognition of this plus value has given to RCA world leadership in the radio, phonograph, television and electronic art.

RADIO CORPORATION of AMERICA

PIONEERS IN PROGRESS

RCA

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of May, 1895)

ALUMINUM BOAT — "The Messrs. Yarrow, of London, have been commissioned to build a small torpedo boat of aluminum, with a view to making a craft that should be very light, and thus be adapted to storage on the deck of a battle ship. The builders adopted an alloy of aluminum and 6 per cent of copper."

PERPETUAL MOTION — "It is but a few years since the mistaken doctrine of the conservation of force was definitely abandoned for the true doctrine of the conservation of energy. Such abandonment indicated a very recent understanding of the true relations of force and energy, for the erroneous expression conservation of force is hardly yet extinct. The many attempts at the production of perpetual motion indicate a want of appreciation of the fundamental bases of science."

JAP COPYISTS — "The war between China and Japan has shown that the Japanese readily turn to account any advantage offered by scientific appliances. Their seizure of the telegraph lines in Corea strengthened their position at once, and any breaks were quickly repaired by men who had been trained in actual construction as well as the manipulation of the instruments. The Japanese are facile copyists."

GASOLINE ENGINES — "The gasoline gas engine, both from a theoretical and practical standpoint, is the most efficient of prime movers. . . This is particularly true of the 'Union' and 'Pacific' engines, built by the Globe Gas Engine Company, for the reason that in their engines the hot gases of the exhaust, usually wasted, are used to heat the air drawn through the vaporizer and into the cylinder. As heat is the essence of the power, the smaller the amount that is wasted, the greater the economy."

ALABASTER — "The alabaster industry dates back to classic times. . . Nowadays, three men, usually relatives, work together in informal partnership, one being a turner, another a modeler, and the third a decorator, who carves such decorative adjuncts on the finished articles as fruit and flowers."

PAVING — "An improved paving consists of concrete made of small lumps of emery stone set in Portland cement. The emery may be in pieces varying from half an inch in diameter down to a powder, and is mixed with Portland cement in the proportion of three parts of emery to two of cement."

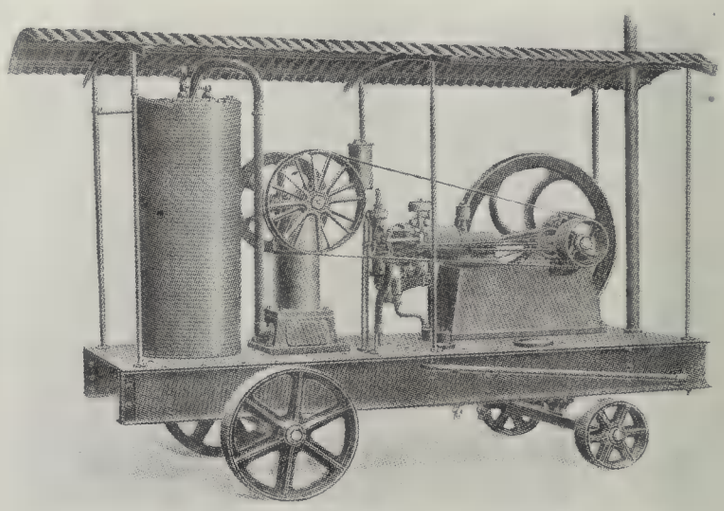
FIRE — "An investigation into the cause of a fire in a dry goods store resulted in demonstrating that an incandescent electric lamp will generate sufficient heat to set flammable material into a blaze. The fire was caused by allowing an incandescent lamp to remain for a few moments on a pile of cotton cloth in the packing room."

HEAT — "Electric heating is now coming to the front, and for certain cases has become a possibility, because of the low economy which seems necessarily inherent in existing domestic processes. It has to compete with heat most wastefully applied; otherwise it would be out of the question except as a matter of luxury. But when to the low economy of the kitchen fire, which is its competitor, there is added its own extreme convenience and cleanliness, it will be seen that a very good case is made out for the employment of the electric current."

SAFES — "The latest burglar proof safes and vaults are magnificent specimens of skillful workmanship. . . The plates are put together, first one of hard steel, then one of wrought iron or soft steel, and so on until the necessary thickness is obtained. From the iron the safe receives its tenacious qualities—it cannot be cracked or broken as easily as steel—and the steel imparts a hardness that defies the burglar's drill."

NIAGARA POWER — "The company which has undertaken to develop electricity, at Niagara, on a large scale, for manufacturing and other purposes, has acquired more real estate there than it needs for its own use, in order to furnish sites to such of its customers as wish to establish their business close to the source of their power supply."

SAND BLASTING — "The uses of the sand blast for ornamenting glass, metals, stone, and other materials is well known. A new application of the process for cleaning down the walls of buildings has been introduced in England. . . It has been used for cleaning the fronts of large public buildings, hotels, etc. Upon a truck is mounted an oil engine which drives



an air compressor which fills an air reservoir to the desired degree of pressure. A flexible pipe conducts the air to the point desired, and blows the sand as required. Building fronts are thus cleaned in a very expeditious manner."

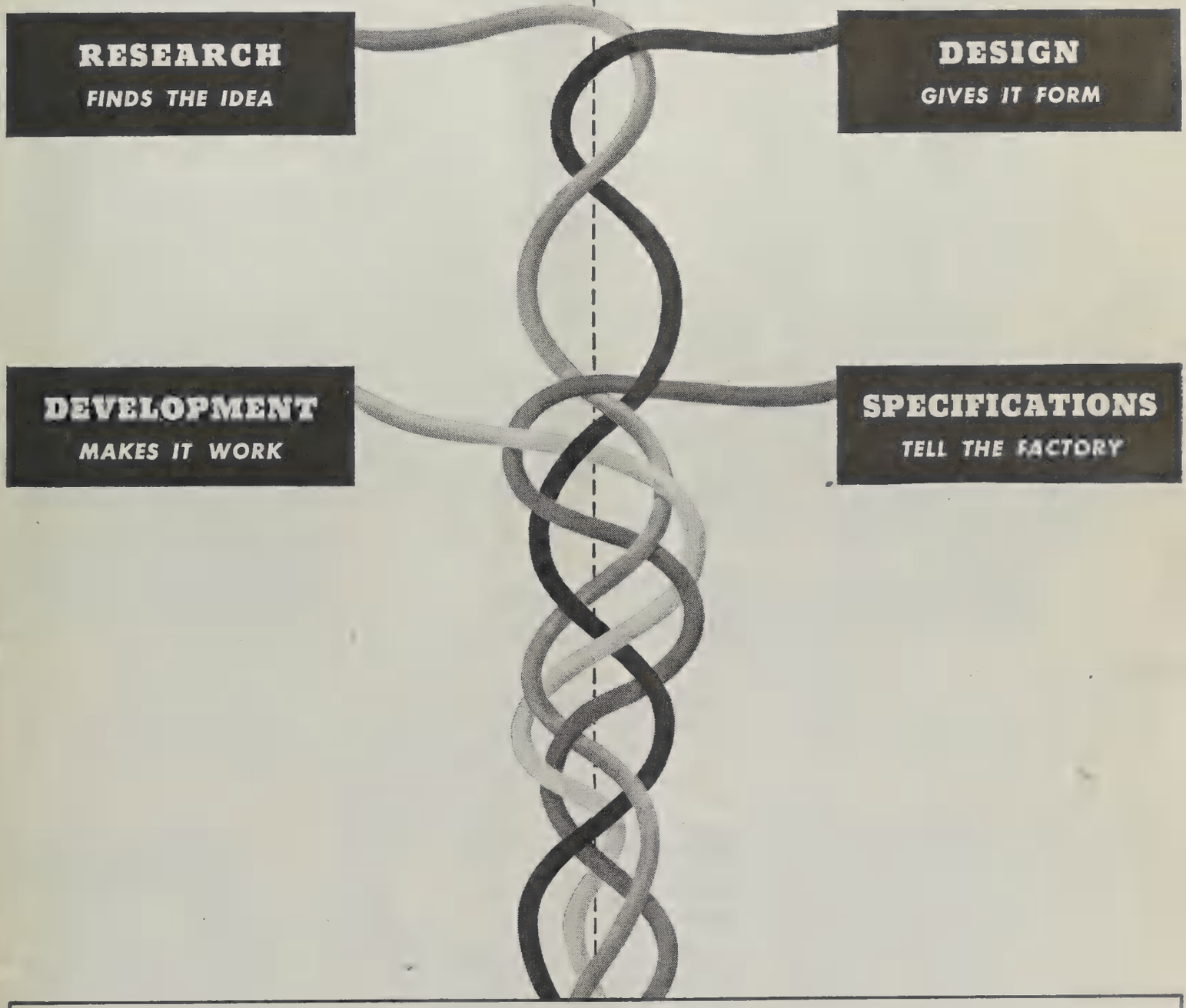
STEAM CAR — "In the competition of automobile carriages held in Paris. . . the steam carriage of M. Scotte, of Epernay, obtained a prize of 500 francs. In this vehicle, which is adapted for eight persons, the boiler is of the vertical type of the Field system and registers 120 pounds to the square inch. The two cylinder motor makes about 300 to 500 revolutions per minute and develops 5 horse power. The power is transmitted to the (rear) driving wheels through an endless chain and a differential gearing. The carriage is 15 feet in length, 6 in width, and weighs, when empty, 3,700 pounds. With 660 pounds of water, 440 pounds of coal, seven passengers and the driver the total weight reaches 5,940 pounds. Consumption of water is from three to four gallons a mile on a level stretch. . . Consumption of coal varies from six to ten pounds, according to the road and the speed."

BARRELS — "It may be economy to use old oil barrels for other purposes, but great care must be taken to clean them carefully, or an explosion may occur which will cause more damage than new barrels would cost."

TOOTHPICKS — "Insignificant articles like the toothpick represent the investment of millions of capital, the employment of skilled labor, utilization of the latest inventions, the consumption of vast quantities of wood, and the operation of a long line of complex activities."

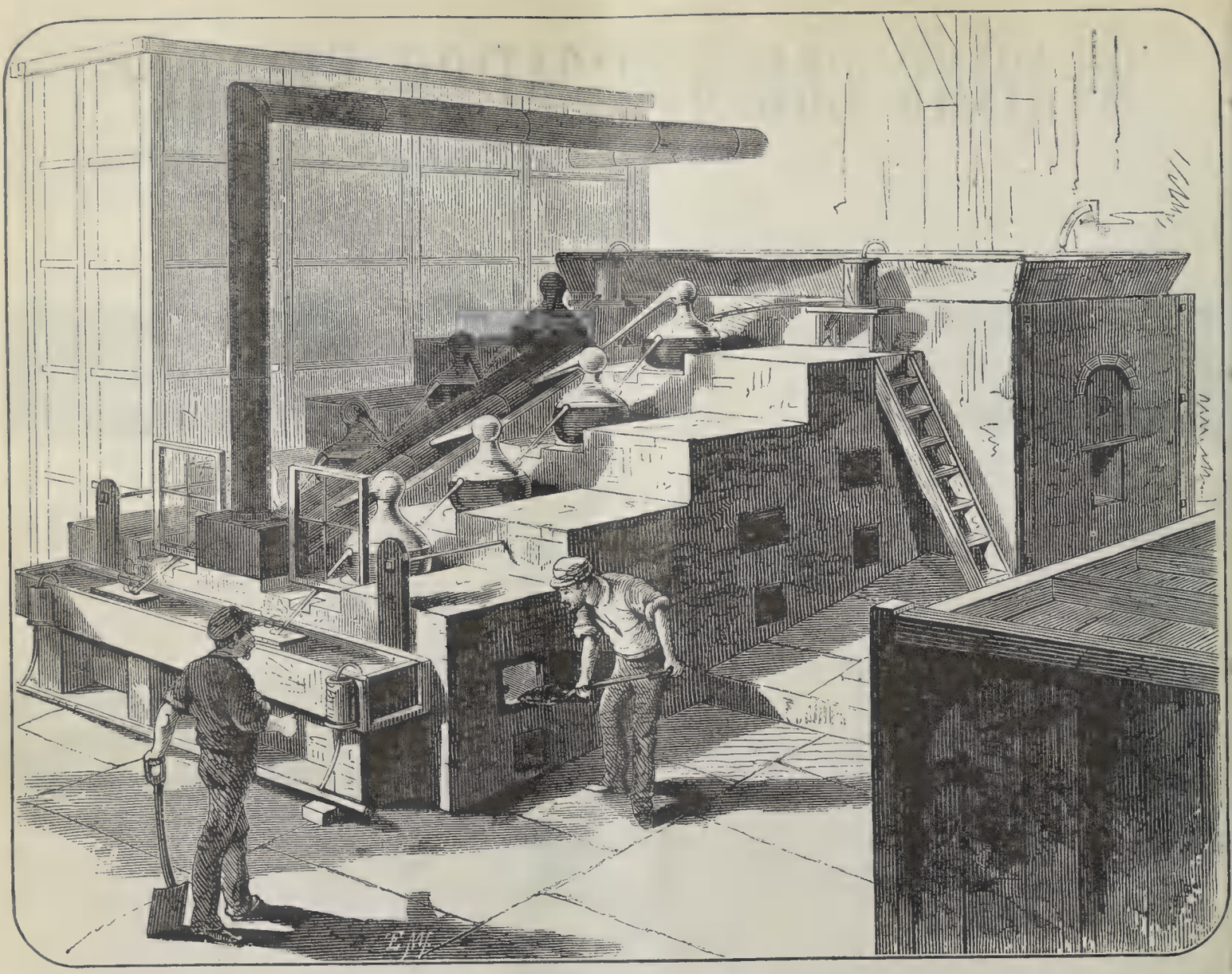
INCENTIVE — "The United States has been prolific of men who, without any advantages, worked their way to the front, and encountering obstacle after obstacle, only grew stronger with opposition. The annals of invention are full of veritable romances of the type indicated. . . Under milder conditions the strong might lack the very incentives supplied by the passive resistance of circumstance."

WEAVING COMMUNICATION HIGHWAYS



BELL TELEPHONE LABORATORIES

brings together the efforts of 2000 specialists in telephone and radio communication. Their wartime work has produced more than 1000 projects for the Armed Forces, ranging from carrier telephone systems, packaged for the battle-front, to the electrical gun director which helped shoot down robots above the White Cliffs of Dover. In normal times, Bell Laboratories' work in the Bell System is to insure continuous improvement and economies in telephone service.



This was Chemistry in 1855

Above: Old woodcut of chamber process for producing sulphuric acid in 1855.

Below: Sketch of a small corner of a 1945 chemical processing plant. This one happens to make penicillin.

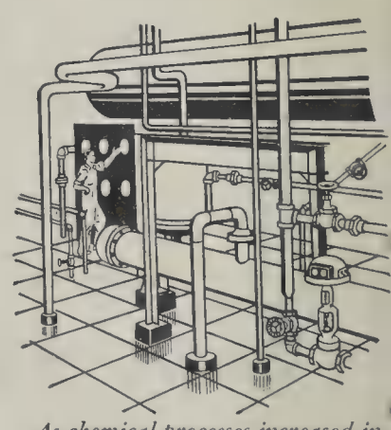
Chemistry was simple in 1855. Hydrocarbons were practically unknown. Fractionating petroleum consisted of boiling off the volatile elements to secure kerosene for lamps. Sulphuric acid was produced by the chamber process illustrated in this old woodcut.

But chemists saw new horizons in their test tubes and retorts. This dramatic research resulted in planned miracles. Whole new industries were born —thanks to the men in the laboratories.

And in the growth of chemistry as in practically every other industrial development that you can think of, piping played an important part. 1945 marks Crane's 90th Anniversary. And since this company was founded it has kept step with this growth, furnishing pipe, valves and fittings to meet the increasing demands of an industrial era as those demands arose.

Year by year, industry changes. New processes obsolete old ones. Huge plants rise, tribute to new developments. A whole era is born through the inventive mind of a scientist. But with all this change, one fact remains constant —it takes piping to make it possible. And supplying the pipe, valves and fittings that industry requires is Crane's job today—as it has been since the company was founded.

CRANE CO. General Offices:
836 S. Michigan Ave., Chicago 5, Ill.



As chemical processes increased in complexity, new demands were made on piping. The Crane line expanded to include specialized piping to meet the requirements of the chemical industry.

CRANE

90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS

Scientific American

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Interior of one of the early Du Pont laboratories, established around 1880 for explosives research

A Century of Chemistry

Although Chemical Manufacture in the United States Was Carried on by the Earliest Settlers, the Real Beginnings of the Chemical Industry in America Must be Placed in About the Middle of the 19th Century

By D. H. KILLEFFER

A THREE-FOLD partnership and interdependence exists between the science of chemistry, the chemical industry, and industry in general. None of these is complete without the others and all prosper or all wane together. The century of American industrial history covered by the life of Scientific American includes all but the early and rudimentary parts of the histories of each of these three vital elements in America.

In the early days of 1845 chemical industry was a magnified version of the laboratories of scientists. The distinction of science from industry in this field was almost indiscernable. The demands of American industry of that day could be readily met with laboratory output. Management, production, sales, and research were the combined responsibilities of a single person in each company. None of the great industries which subsequently were to demand huge quantities of chemicals had yet reached beyond the most rudimentary stages. Many of them had not yet been conceived. And because chemical manufacture has always converted raw materials for use in other industries, its growth in a modern sense had not yet properly begun. The products of its plants were only those things which could not be conveniently imported from abroad, notably sulfuric acid, potash recovered from plentiful wood ashes, a few paint pigments, natural dyes extracted from barks, woods, and berries, and a few other strictly chemical products.

The pace of life and industry in 1845 and earlier was such that we can reasonably connect the chemistry of that time with beginnings. By modern standards the science of chemistry began with Lavoisier, a Frenchman who lost his life in the French Revolution a bare half century before our story begins. And another Frenchman, Nicholas Leblanc, had in 1791 created what is now considered to be the definite beginning of the modern chemical industry, the Leblanc soda process.

It is of course true that a vast deal of chemistry of a sort had been practiced long before Lavoisier's time; but Lavosier, by introducing weighing into his experiments, converted the quasi-magic of earlier chemical experimentation into the modern exact science. Similarly, many chemical processes had been practiced centuries before Leblanc devised his process for converting salt, which was plentiful, into soda, which the French of his day badly needed. But the fact of Leblanc's deliberate intent to devise a process to transform by chemical means a cheap raw material into an expensive product differentiates modern chemical industry from all that went before.

Both of these pioneers had earnest and eager followers in the America of 1845. True, the number of these followers and the extent of their activities were rather severely circumscribed by the fact that American industry was only

beginning its later immense expansion. The transfer of the traditional household arts into the factory and the creation of new industries to utilize and elaborate American natural resources into a thousand useful products can scarcely be said to have begun by 1845.

DIFFERENT VIEWS — In all of this history, one must always bear in mind that there are three quite different ways of looking at American chemical industry. One school of thought sees chemical industry in any practice of any chemical process and discerns its beginnings in pre-historic times. That would make American chemical industry practically co-existent with European settlements on this continent. The colonists at Jamestown, Virginia, included products (tar and potash) within that definition in their first exports made before the landing of the Pilgrims; and John Winthrop, the Younger, actually initiated chemical manufacture of a type in New England as early as 1635.

A second point of view is based on a conception of chemical industry typified by Leblanc's indubitably chemical-economic invention: chemically converting one material into another at a price and a profit. If we narrow our definition to fit that conception, then the beginnings of American chemical industry must be dated from sometime about the period of 1845. The development of an American industrial consciousness behind a wall of protective tariff had progressed by that date to a point where a number of chemical enterprises had already begun to assume forms not unrecognizably different from those of today. Thus one can reasonably date American chemical industry from some rather indefinite years—since there appears no outstanding event from which to date a clear-cut beginning—about a century ago.

A third point of view would date the ultra-modern period of chemical industry in the United States from World War I. The very substantial and active chemical industry then in the United States was deeply overshadowed by those parts of it which were virtually, if not totally, lacking; notably the synthetic organic division of the industry producing dyes, many vital pharmaceutical chemicals, synthetic odors and flavors, and some of the chemicals essential in photography. This deficiency possessed a certain economic justification stemming from the fact that in chemical manufacture, as in other industries, cost goes down as quantity of production increases. The Germans, who had early seized the initiative in the field, consequently were able to produce the world's needs in organic chemicals at cheaper unit prices than any other single nation could produce its own.

By the beginning of World War I, chemical industry had progressed far from the weak beginnings of 1845 but its character had not essentially changed. Management and research were still often the same persons. Small companies had grown, some of them—but very few—even approached greatness. Yet none of them had reached the stage of attracting outsiders. Organizations of many kinds had knit the industry and the profession of chemistry into a coherent brotherhood that looked with something akin to disdain on other less enlightened industries. Many chemical commodities were made abroad in quantities and imported at



The first Du Pont chemical laboratory, where research was carried out on improved methods of refining salt-peter, was located on the Brandywine

prices far below production costs here. This left great gaps in the sufficiency of the industry to be revealed by World War I and its accompanying embargoes.

Those gaps in the completeness of our chemical production provided a stinging goad to development. Whatever may have been the other benefits of that war, and they were very small as events have proved, its stimulus to American initiative was the most valuable. Under the necessity of catching up with the rest of the world, Americans set earnestly to work and the habit of research was firmly planted in the minds of our industrialists. Its fruition during the inter-war period has been abundant.

MILEPOSTS OF PROGRESS—To select any particular event in the history of chemical industry as originating within it and as afterward affecting the outside world is extremely difficult. Similarly, it is difficult to choose an event brought about within chemical industry entirely by external forces demanding solution of a particular problem. Here, as in other fields of endeavor, the processes of development are revolutionary and interdependent and flow through time as a continuing current. Hence, any historical scheme must emphasize the effects of chemistry and chemical industry on others, and then reverse the process and examine the effects of wholly external causes on the chemical industry's progress. Here are a few:

Solvay Soda Process—We have mentioned the Leblanc process of manufacturing soda from salt as the earliest clear-cut case of purposeful and planned chemical manufacture. It was an effective process and had consequences, as the chemical habit is, far beyond expectations. While Leblanc's process, using large amounts of sulfuric acid, produced the desired soda, it yielded at the same time large quantities of highly objectionable hydrochloric acid gas and solid calcium sulfide. Both of these wastes possess

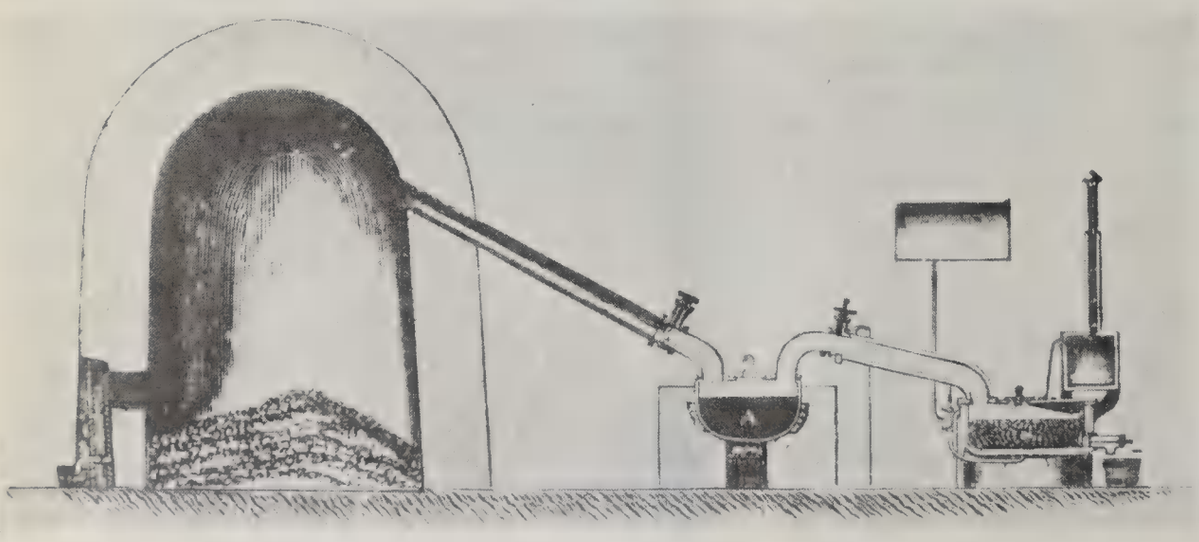


Diagram of a sulfur refinery of the middle 1800's, in which distilled sulfur was delivered to the water-cooled vessel at the right. This type of sulfur was preferred for the manufacture of gunpowder

a certain value to an integrated group of other chemical operations. But without such related processes the problems of disposal were serious handicaps to Leblanc soda plants. Conversely, once the integrated chemical structure was established, the complete utilization of all products put the Leblanc soda plants in enviable competitive positions against any influence from the outside that would upset them.

This situation was early established by the British who seized upon the Leblanc process before it could be fully established in France, and adopted it as their own. It gave the British a strong hold upon the world's alkali business which they maintained over a long period of time and which led to a certain disdainful complacency toward a new and promising soda process developed by the Belgian, Ernest Solvay, in 1863.

Solvay's process, which avoids much of the complexity of the elder Leblanc process, consumes salt and limestone —plus water and fuel—and produces only the desired soda and a by-product of calcium chloride, which is far less objectionable than hydrochloric acid or calcium sulfide.

The refusal of British chemical manufacturers to upset the delicate equilibrium of their enterprises to use the new process sent its promoters to the United States. Here it was eagerly adopted as a means of rendering American industry independent of British alkali, which had previously supplied demands here at prices discouraging the heavy investment necessary to establish the Leblanc process on this



The brine well utilized by Dr. Herbert H. Dow in his early work (about 1890) on extraction of bromine

side of the ocean. In spite of its alien origin, the Solvay process can be said to have become thoroughly American through adoption. It is the principal dependence of the United States for soda alkalies and it supplies all these essential products except for caustic made by the electrolytic process.

Sulfuric Acid—No chemical compound or product of chemical industry approaches sulfuric acid in importance. It is universally required in chemical operations of all kinds, the *sine qua non* of the industry for its own use as well as the largest single product in its output to other industries.

In the United States the two ruling demands for sulfuric acid came from the fertilizer industry and from the petroleum refineries. German chemical industry, developed primarily around the production of synthetic dyes and related compounds from coal tar, early demanded sulfuric acid of a high strength beyond that economically obtainable from the chamber acid process and consequently the contact acid process found ready acceptance in Germany where it was developed to commercial practicability.

The lead chamber process of sulfuric acid manufacture was first developed in England before the time of the American Revolution. The principal characteristics of the process are: a chamber plant will continuously produce low-strength sulfuric acid—70 percent concentration or less—which must be concentrated and purified for many purposes; it can use impure by-product sulfur dioxide as a raw material without affecting the operation of the plant, and hence it is convenient to utilize smelter waste gases; and finally the plant requires a minimum of skilled labor once the process is in operation.

The expense of concentrating chamber acid fostered the development of what is known as the contact acid process. This process was developed in England in 1831 but was of limited usefulness until Frasch invented a method of mining the huge deposits of pure sulfur on the American Gulf Coast and made this raw material cheaply available.

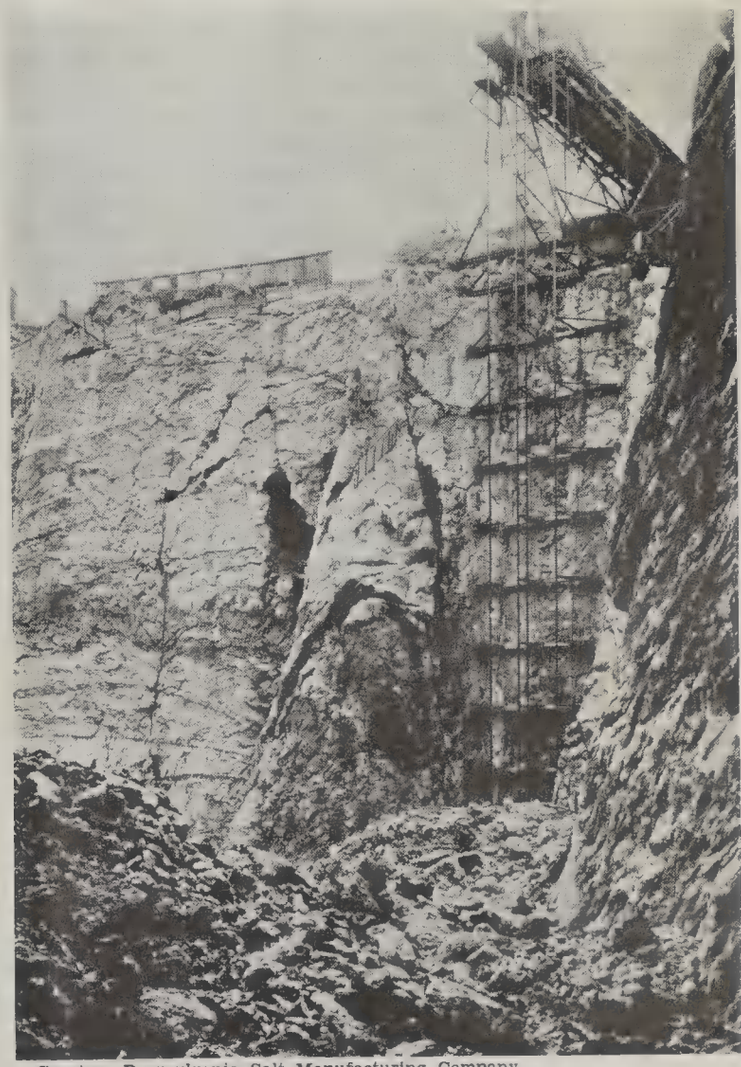
The contact process was introduced into this country shortly before 1900. Now more than half the United States' peace-time production of sulfuric acid comes from contact plants which have replaced older chamber plants and have made old-time acid concentration obsolete.

Frasch Sulfur Mining Process—It is difficult to overestimate the significance of the vast supply of sulfur of highest purity which the Frasch process made available at low cost to chemical industry. Sulfur deposits of enormous extent were long known to exist in deep-lying strata in the Gulf Coast area but overlying these were thick layers of quicksand which had proved an impenetrable barrier to ordinary mining methods.

Herman Frasch devised the method now employed to melt the sulfur underground and bring it to the surface in liquid form. The mine consists of concentric pipes down one of which superheated water (100 pounds gage pressure) is forced and up another of which flows the sulfur melted below ground in the original deposit. Compressed air is forced down a third pipe to act as an air lift and assist in pumping the water-sulfur mixture to the surface.

This process has yielded as much as 2.5 million tons of pure sulfur annually and has rendered other sources of sulfur practically obsolete. Exceptions, of course, are sources of by-product sulfur which must be recovered to prevent damage to the countryside, as at smelters. Here recovery of sulfur fumes, usually by conversion to sulfuric acid, is mandatory.

Petroleum Refining—Discovery of oil in a well drilled



Courtesy Pennsylvania Salt Manufacturing Company

A mine in Greenland from which comes cryolite used in making aluminum and in glass and ceramics



In the early days of Monsanto Chemical Company, mules furnished power for transportation of materials and products. Contrast this mule-and-wagon combination with modern, lightweight railroad cars especially designed for handling chemicals of all kinds in lots of thousands of pounds each, often under pressure and always with safety to the chemicals and the cars alike

for brine at Tarentum, Pennsylvania, in 1845 led to a thorough investigation by Benjamin Silliman, Jr., of Yale University, into the properties of "rock oil"—petroleum. From that chemical investigation of oil and the products of its distillation dates the oil industry. In 1859 Colonel Drake's famous oil well was completed, the first deliberately drilled to obtain oil, and the industry was on its way. That was an important event chemically as it was in many other ways. The refining and later the elaboration of petroleum are both consumers and producers of chemicals in huge tonnages.

Refining petroleum distillates consumes the second greatest quantity of sulfuric acid of any single use, being exceeded only by fertilizer manufacture. Here it is employed to dissolve out undesired compounds and leave the pure hydrocarbons. Other treatments of the same group of processes consume caustic soda and soda ash and lead oxide in removing objectionable impurities, particularly sulfur compounds. Solvent refining of lubricants utilizes the selective solvent power of such compounds as furfural to effect other separations difficult or impossible by distillation.

Development of the cracking process by Burton in 1913 created a new and strong link between the petroleum and the chemical industries. Cracking in essence consists in breaking the large molecules present in petroleum into smaller ones by the application of heat and pressure.

Built upon the original cracking processes are modern reforming processes which control catalytically the recombination of the molecular fragments produced in the cracking zone and, what may be even more vital in the long run—as it is now in war—the conversion of petroleum hydrocarbons into benzene, toluene, and other compounds previously obtainable only from coal. These are essential to military explosives and synthetic rubber.

Production of high octane aviation gasoline, essential today and likely to have revolutionary consequences in future transport by air and highway, similarly knits chemical industry closer to petroleum. The discovery in 1922 by Midgley of the extraordinary effectiveness of tetraethyl lead in suppressing detonation in spark-ignited internal combustion engines marked the beginning of a new era of efficiency of these prime movers. This development has had important chemical consequences in the production of tetraethyl lead itself, in the chemical transformation of the various fuels derived directly from petroleum into more desirable forms, and in the recovery of bromine by new techniques from sea water to form a constituent of one of the necessary modifiers required with tetraethyl lead.

Fertilizer Production—Exceeding petroleum refining as a consumer of chemical industry's basic product, sulfuric acid, is the production of fertilizers. As early as 1855 mixed fertilizers based on the theories of the German chemist Liebig were produced in the United States. Essential constituents of a mixed fertilizer are potash, nitrogen (in the form of a compound), and phosphorus.

Potash salts generally are soluble in the soil solution that feeds plants and hence can be used in suitable dilution in mixed fertilizers. Usually, however, the potash salts preferred are the chloride and the sulfate, which can be prepared from any others available. Previous to World War I, American farmers were entirely dependent upon potash from German-controlled mines for this essential. Now, however, mines in New Mexico supplemented by potash salts recovered from the dry Searles Lakes in California and a few other sources, provide ample domestic supplies.

The cases of nitrogen and phosphorus differ in requiring chemical intervention of an important sort to make useful to plants the natural products in which these elements occur.

Compounds of nitrogen are distinctly scarce in nature but nitrogen itself, which is of itself quite useless as fertilizer, comprises four fifths of our atmosphere. During the



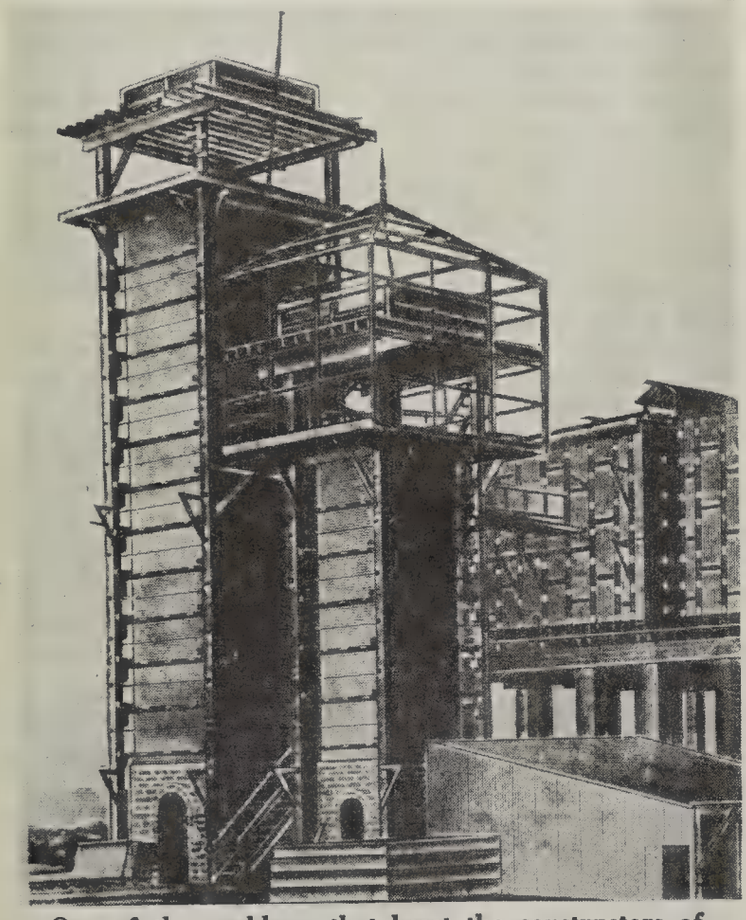
Courtesy Merck and Company

A chemical packaging "production line" of 1893

latter part of the 19th Century methods were devised and put into successful practice for utilizing atmospheric nitrogen, but their application was limited and it was not until the method of synthesis of ammonia was discovered in 1912 by the German, Fritz Haber, that the problem of nitrogen for fertilizer could be said to be solved. This process requires only minor amounts of power. The ammonia produced can be converted into any of a number of forms for application to the soil. Smaller, but still substantial, is the ammonia by-product of coke ovens and gas works used commonly as ammonium sulfate.

Phosphorus occurs abundantly in phosphate rock but this too is unsuitable for direct use as fertilizer. Treatment with sulfuric acid converts the ground raw rock into acid phosphate, the most simply prepared form of available phosphorus.

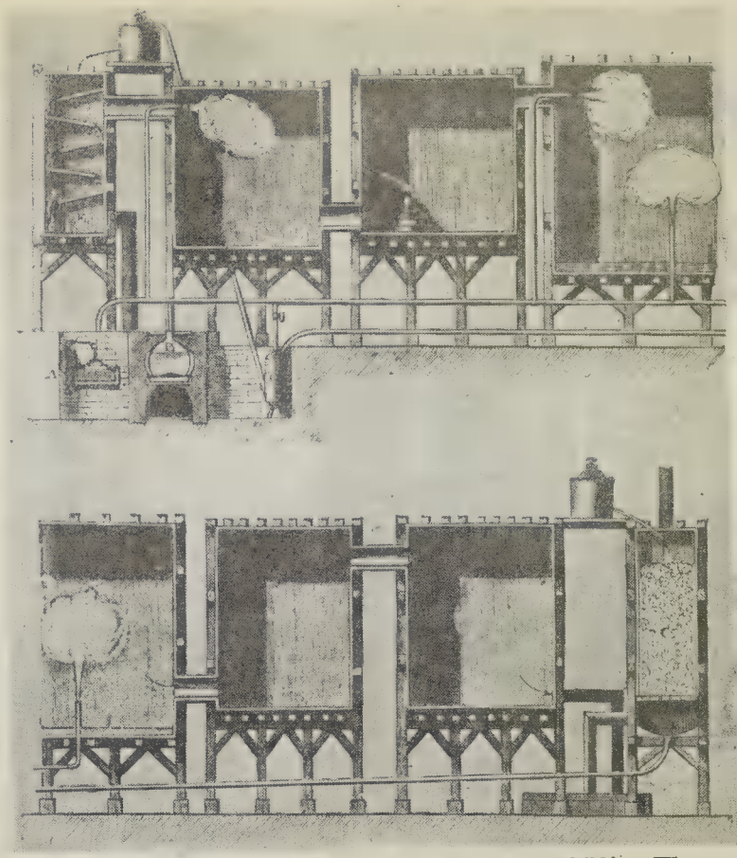
The subject of fertilizer suggests the many other products of chemical industry vital to agriculture. Insecticides and fungicides produced in volume and variety by chemical industry protects seeds, crops, and the harvested produce from destruction by pests. Similarly, veterinary medicines and other chemicals protect livestock. Latterly, certain substances found to have controlling effects on the growth and development of plants, the so-called plant hormones, promise new usefulness for chemical industry's products in agriculture.



One of the problems that beset the constructors of 19th Century sulfuric acid plants was that of erecting timber towers strong enough to carry the load

Photographic Chemicals—The photographic process, still new at the beginning of the century we are considering, was based on the chemical effect of light and has thus had important chemical consequences. The preparation of sensitive plates, films, and paper, as well as the processing of these, consumes huge quantities of the products of chemical industry. Furthermore, the discovery by Ives in 1893 of the half-tone process opened a new field for the graphic arts and at the same time created a new demand for chemicals.

Chemistry in Medicine—The introduction in the 1840's of anesthesia and the use of ether in surgery may properly be said to have opened a new era for both chemistry and medicine. The names of Long, Morton, Warrne, Wells, and Jackson figured largely in the controversies which raged over credit for this American discovery which revolutionized



A sulfuric-acid chamber plant of the 1870's. The contact process later offered great competition

surgery quite as truly as antisepsis did later. Production of ether may be considered to be the first large-scale organic chemical synthesis of a substance to meet a defined need of medicine. Other medicinals previously made had been largely extractive or simply of mineral origin.

Subsequently an entire large section of American chemical industry has developed to supply the needs of medicine by production or purification of chemicals. Included today are the sulfa drugs, several of which were originated in this country, penicillin, anti-malarial drugs, a range of antiseptics, chemicals for producing various degrees of anesthesia and hypnosis, synthetic vitamins, and the broad requirements of chemical remedies and alleviators of suffering.

Plastics—The industry built upon Hyatt's Celluloid of 1869 and more definitely on Baekeland's phenol-formaldehyde resin of 1907 has reached such proportions and acquired such stature both as a consumer of chemicals and producer of values to justify separate treatment by Charles A. Breskin in the feature article next following.

Electricity and Chemicals—Morse's telegraph, Edison's electric light, Bell's telephone, and De Forest's vacuum tube have each required the chemical industry to supply certain essential materials needed for their full operation. The electric batteries of the early, as well as later, days are distinctly chemical products and have consistently required high purity chemicals in their construction. Insulation, as well as copper wire of the high purity essential to high conductivity, tungsten filaments in lamps, and chemicals needed to remove residual gases from electric lights and vacuum tubes are all products of chemical industry, as are the phosphors employed in modern fluorescent lights and the gases which glow in neon and similar gaseous discharge lights.

Chemical industry has built two of its important divisions on electric developments, the electrolytic chemical industry and its running mate, the electrothermal industry. The first produces primarily pure metals—copper, aluminum, magnesium, and manganese, particularly—caustic soda, caustic potash, and chlorine. The electrothermal division of chemical industry produces artificial graphite, silicon carbide, and boron carbide abrasives, many metals and their alloys, and calcium carbide.

Rubber Chemicals—Goodyear's discovery of the vulcanization of rubber in 1839 was fraught with great consequences for American chemical industry. A century later



Courtesy American Cyanamid Company

Synthetic resins being made on a pilot-plant scale bridging the gap between laboratory and factory

rubber manufacture consumed huge quantities of a wide variety of specifically designed chemicals intended to improve and modify the properties of the finished product. Latest development is the synthesis of a number of valuable rubberlike synthetics to replace the natural product.

COMPANY GROWTH—A company may develop, spread, and grow from within outward; or it may draw other companies, possessing something of value to it, into amalgamations and mergers. Of the first type, the outstanding example in chemical industry is probably Dow Chemical, which thrives alone with a minimum of external alliances. Typical of the second kind of growth is the American Cyanamid Company, which has reached substantial size by the merging of a number of small companies.

One may clearly distinguish three *methods* of growth among chemical companies. A single raw material may be elaborated to a single group of closely related products and by-products. The alkali companies have grown this way from the processing of rock salt and the manufacture from it of the essential alkalies, soda ash, caustic soda, bicarbonate of soda, chlorine, bleach, dry ice, and lately even magnesium.

Although it has now grown far beyond the bounds of any such plan, the development of the Du Pont companies, largest in the chemical group, illustrates a second method of growth based on full utilization of a particular technique followed now in all of its potential ramifications. The explosives manufacture of Du Pont required the development of its own heavy acid production for converting cotton and wood pulp into the nitrocellulose of smokeless powder and for making dynamite and nitroglycerine from the glycerine by-product of soap making. The limits of explosives were too narrow for vigorous growth within the organization and step by logical step its energies have been given exercise in following up the leads to new lines developing out of explosives manufacture. Gradually this has led to lacquers, paints, varnishes, rayon, dyes, medicinal chemicals, dry cleaners' solvents, refrigerants, synthetic rubber, and the broadest of all chemical producing programs. In a sense this is similar to development based on raw material advantages but more essentially it follows the evolution of techniques.

Similarly, the original development of Monsanto was based on the expansion of the techniques of organic chemistry to yield diverse products from coal tar and at the same time production of needed raw materials. Lately the list has grown to include products made from petroleum, natural gas, and phosphate rock.

The third type of growth of chemical industry is based on a primary purpose to supply a particular group of needs. Merck, developed from a pharmaceutical beginning, exemplifies this in confining its manufactures to chemicals required by pharmacy and medicine and others closely related to this field. This leads to close attention to a particular group of needs and the technique of supplying them. Naturally this limiting of market objectives materially simplifies the problem of sales while complicating that of diverse production.

Illustrations of these types of development are difficult to find uncomplicated by other factors and influences. Thus the development of Union Carbide has partaken of all of these schemes from time to time. Its manufacture of calcium carbide in the electric furnace left but a short step to the Presto-Lite Company, large consumer of calcium carbide for the manufacture of acetylene. The slow death of acetylene lighting and the rise of oxy-acetylene welding encouraged the merging of Linde Air Products, producer of oxygen from liquid air. The electric furnace skill of the parent company naturally brought in National Carbon, maker of electric furnace carbon products. Already this technique had been employed in metallurgy of alloys by Carbide's Electro Metallurgical subsidiary. At the time Presto-Lite entered the merger, it had already been actively seeking other sources of acetylene to free it from Carbide's dominance. These efforts had not succeeded in reaching their objective but had unearthed promising leads for further development. The original plan was to make acetylene not from calcium carbide, product of coal, lime, and electricity, but by transformation of oil or natural gas. Failure to reach an economical and practicable method of circumventing Carbide's position was not fruitless. In the trying, numerous other products were found which could be profitably made from natural gas or oil even though acetylene could not. The result was the formation of Carbide's chemical subsidiary for exploiting this new field, now a vital element in the company.

Tomorrow chemical industry will continue to supply new and better products for tomorrow's living. Many of these products are now working for war as they will work for peace. New synthetic fibers and plastics will vie with chemical modifications of those which nature provides. Trees in the East Indies will have to compete with petroleum wells in Texas in the world rubber markets. New medicines of power yet scarcely imagined will cure such rare diseases as are able to penetrate the strong health armor of a vitamin-fed race. Color photography, television, radio, aviation, rockets . . . these and countless other yet unborn necessities of the future will be built upon science materialized by an expanding chemical industry.



Courtesy Du Pont

An explosives test in 1896, using a "ballistic mortar" to measure explosive energy by means of the recoil

Plastics Through The Years

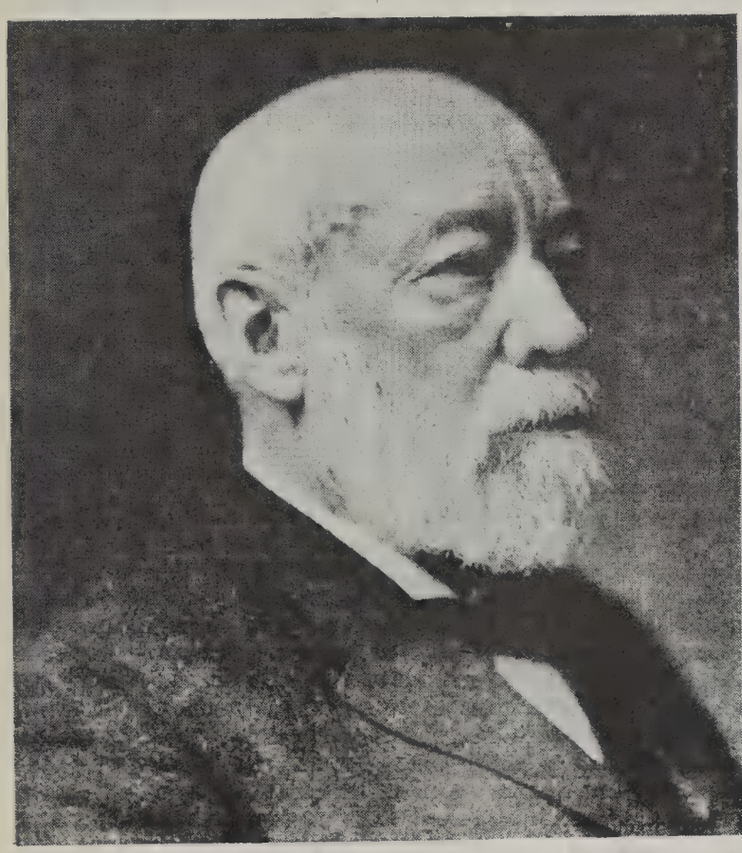
From Hyatt's Original Celluloid through Baekeland's Epoch-Making Bakelite to the Most Recent Discoveries in the Plastics Field, the Record has been One of Progressive Achievement. Out of the Welter of Present Plastics Will Come Even Greater Triumphs for the Future

By **CHARLES A. BRESKIN**

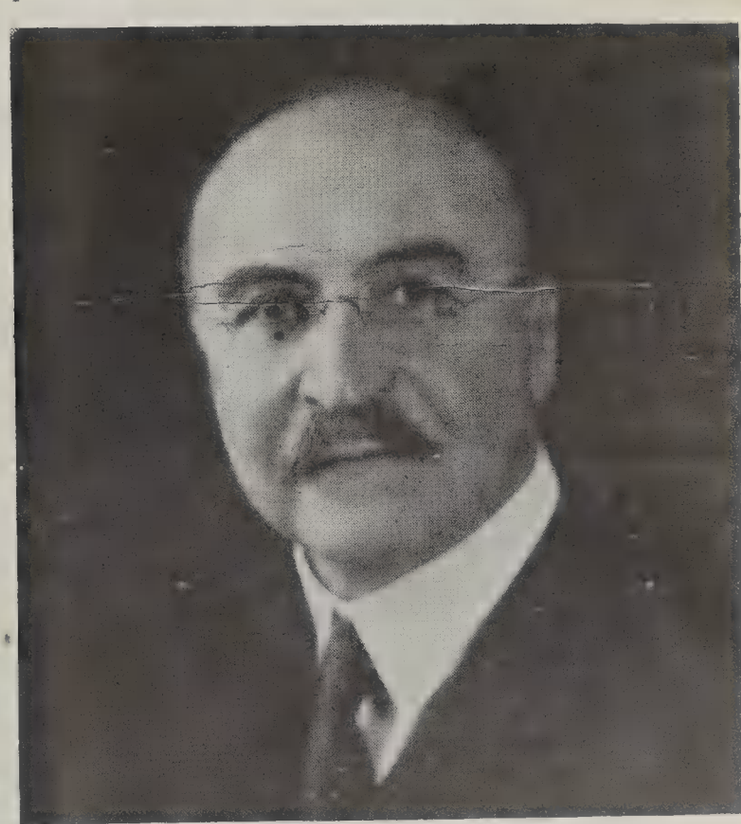
THE DISCOVERY and development of plastics have been conceived by one artist as a billiard ball, surface etched with the map of the world, which, when struck by a billiard cue, explodes into a myriad of tiny bits that take the form of the plastics products which are such an essential part of present-day living. Oversimplified, giving no hint of the years of research involved in the development of each of the many different materials used in the products thrown off by the bursting ball, this drawing is yet correct in its basic ideas—the billiard ball did supply the impetus for the development of the first commercial plastics.*

CELLULOSE NITRATE—In the decade after 1850, a serious shortage developed in many of the natural materials used in the decorative arts—tortoise shell, ivory, and amber. Decimation of the great elephant herds, in particular, brought the supply of ivory so far below the demand that prices of ivory articles went sky high. Since the chief commercial outlet for ivory was in the manufacture of billiard balls, the price and supply situation led the American firm of Phelan and Collender to offer a reward of $10,000 to whoever could invent a substitute for ivory which would be suitable for fabrication into billiard balls.

As a result of his determination to win this reward, John Wesley Hyatt, a young printer, is generally credited as being the first to work with cellulose nitrate as a plastic mass rather than in solution. Hyatt, however, hit upon the idea of using solid camphor and making the collodion by dissolving pyroxylin under pressure and with a minimum of solvent. The first patents were taken out in 1869 in the names of John Wesley Hyatt and his brother, Isaiah. Improvements in the process of mixing the pyroxylin and camphor were noted in patents issued in 1870 and in 1872, and the name "Celluloid" was coined for the product.



John Wesley Hyatt . . . Celluloid . . . 1869



© Underwood and Underwood

Dr. Leo H. Baekeland . . . Bakelite . . . 1909

Although the Hyatts are credited with having manufactured some very acceptable billiard balls, there is no record of the $10,000 reward having been paid to them—or to anyone else. However, the need of dentists for a satisfactory substitute for hard rubber in denture plates soon engaged the interests of these two men, and the Albany Dental Plate Company was organized in 1870 to handle this first application of the cellulose-nitrate-camphor plastics. By January 28, 1871, the demand for the material for miscellaneous uses had become sufficiently great to bring about the formulation of the Celluloid Manufacturing Company, the predecessor of the Celanese Plastics Corporation of America. The material is now made by many manfacturers and is known by many other trade names.

Despite the fact that the material is somewhat hazardous

*Much of the information in this article is based on "A History of Plastics," by Gordon M. Kline.

to handle, is readily decomposed by heat, and is unstable to sunlight in its unpigmented form, it has been, until recently, the best available thermoplastic material for many purposes because of a variety of unique properties. Its ability to take color, and the many distinctive mottled and variegated effects that may be obtained, were among the boasts for early Celluloid articles.

SHELLAC—In the commercial development of plastics materials, molding compositions containing shellac are listed second. However, in actual chronology, the basic ingredient of these compositions is the oldest of all the natural substances that enter into modern plastics. Shellac is produced by an insect which lives upon certain trees in India and Southern Asia. It has been known and utilized for many centuries for various purposes, such as a component of sealing waxes, polishes, and varnishes. Some of the patents relating to its use in molding compositions are contemporary with Hyatt's discovery of pyroxylin plastics. However, the first application of any magnitude for shellac molding compositions dates from its use by Emil Berliner in 1895 for phonograph records.

About 1900 shellac was adopted for electrical insulation, and it is still used in insulators for very high voltages because it offers good arc resistance and does not burn if a flash passes over the surface. Developments in recent years have been primarily in its application as a resinous binder for cloth, paper, silk, mica, and other insulating materials.

BITUMINOUS PLASTICS—The third plastics material to become industrially important in this country was of bituminous origin, utilizing asphalt, pitch, coal tar, and so on. It is more commonly known as *cold molded.* Emile Hemming was the pioneer in its development in the United States and introduced it on the market in 1909. His purpose was to "produce a commercial heat-resisting molded insulating product for extensive use, particularly in the electrical, the wiring device, and the automotive fields." The great advantages of the cold-molded products were in the saving of time over that required for other purposes, their excellent resistance to heat, and their comparatively low cost; but improvements in phenolic materials have caused great inroads into the application of this material in recent years.

PHENOL-FORMALDEHYDE RESINS—The first and most versatile of the commercial synthetic resins, the phenol-formaldehyde condensation product, was introduced and patented in this country in 1909 by Dr. Leo Hendrik Baekeland. Dr. Baekeland's research took up the thread where several predecessors had tried and either failed completely or dropped their work for other interests. In 1909, contemporary with the bituminous plastics, Dr. Baekeland received the so-called *fifth-mol* patent in which it was indicated that a heat-hardenable resin could be produced by using an alkaline catalyst in proportions not exceeding 20 percent of the total mixture. A later, *heat and pressure,* patent covered the technique for quickly converting this resinous product into a molded article of excellent mechanical and electrical properties. Other patents for making solutions and for their use in laminated articles followed in rapid succession.

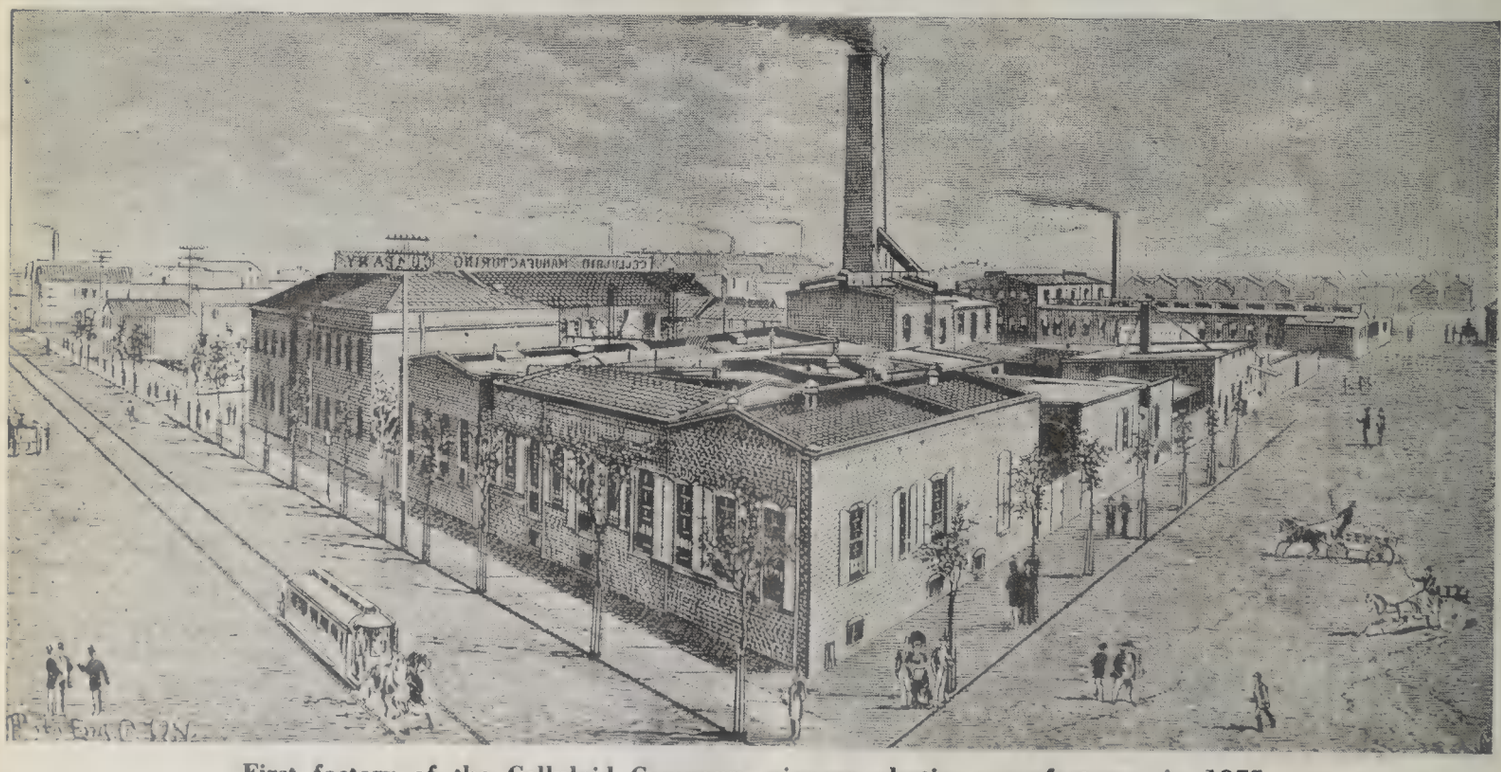
The manufacture of Bakelite was begun in Dr. Baekeland's laboratory in 1907. The General Bakelite Company was organized in 1910 and was merged in 1922 with the Condensite Company and the Redmanol Chemical Products Company into the Bakelite Corporation. Since the expiration of the basic patent in 1926, many other firms have marketed phenolic resins under various trade names. An important modification of this general type of resin is the use of furfural in the place of formaldehyde for the condensation reaction with phenol. Patents for the preparation of these resins, involving the use of both basic and acidic catalysts and no catalysts, have been granted to E. E. Novotny (Durite Plastic, Inc.) and others, and these products have been on the market since 1922.

Enormous quantities of phenolic plastics have been used in the automotive industries, later in the radio, and most recently in the communications and aircraft industries. The use of phenolic resins as bonding agents for other materials opened up another entire field of development.

CASEIN PLASTICS—Although formaldehyde-hardened casein plastics was discovered in Europe and its manufacture begun about 1900, its commercial development in this country did not get under way until after the original patents had expired. The pioneer for casein plastics in the United States was Christensen who introduced Aladdinite in 1919, and by 1925 four other American firms were in production. The primary limitation on its more extensive use is its hygroscopicity which leads to warping and cracking of the plastics when subject to wide variations in relative humidity.

Mention should also be made here of the research and development work which is under way to utilize proteins from sources other than milk as raw materials for plastics. Chief among these are soybean protein and zein obtainable from corn.

CELLULOSE ACETATE—A period of very active development of new plastics materials in this country started with the appearance of cellulose acetate in the form of sheets, rods, and tubes in 1927. The firm which pioneered in the development of pyroxylin plastics also introduced cellulose acetate plastics to the American market. This was accomplished



First factory of the Celluloid Company, pioneer plastics manufacturer, in 1875

by a combination in 1927 of the Celluloid Company with the Celanese Corporation. For two years the new corporation's cellulose acetate plastics was available only as sheets, rods, and tubes; but in 1929 the first cellulose acetate molding powder was marketed. The advent of the injection molding press greatly increased the speed with which molded articles could be produced; the wide range of colors available, the adaptability to all sorts of applications, and the generally excellent properties have made this material most popular. Both the plastics and the molding powders are now available from several commercial sources and are being satisfactorily applied to the production of innumerable consumer articles that are finding ready acceptance by the general public. This plastics material, along with many others, is also being adopted by industry for many work-a-day purposes.

UREA-FORMALDEHYDE—The appearance of the urea-formaldehyde resinous molding compounds on the American market in 1929 meant the extension of unlimited color possibilities into the field of thermosetting molding. The American Cyanamid Company were pioneers in the marketing of the new type of synthetic resins, and in 1931 a similar product was introduced by the Toledo Synthetic Products Inc. (later the Plaskon Company). The extensive use of urea plastics in the illuminating industry has resulted from their efficiency in providing a diffused light, plus their lightness of weight and shock resistance. These resins have also been introduced into the field of laminated plastics in order to take advantage of the many stable colors in which they are available. They are now produced by several other companies.

MELAMINE—Melamine resins are among the comparative newcomers in plastics, having been introduced by the American Cyanamid Company in 1939. However, melamine itself dates from the early days of synthetic organic chemistry. Many of its reactions are similar to those of the urea-formaldehyde materials, and it has been utilized in many of the same applications. The material is now produced by a number of companies.

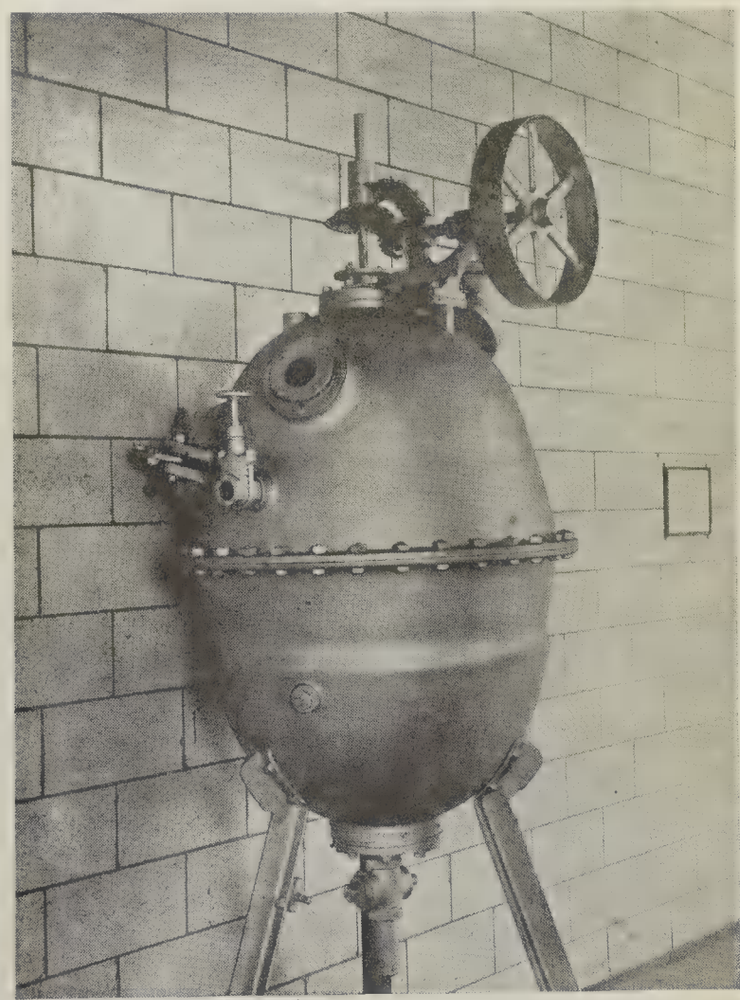
CAST PHENOLIC—A phenolic resinous product, distinctly different from the early Bakelite type in appearance, processing, and field of application, was put on the market in 1929 by the American Catalin Corporation. These cast phenolics



owe their popularity quite largely to their beauty and decorative value. However, their widening use has also been brought about by their ease of fabrication and other favorable properties. They are now manufactured by several of the larger companies.

VINYL RESIN PLASTICS—The polyvinyl ester resins have been known for over a hundred years, yet their commercial development in this country began only about 15 years ago. The most important of these resins industrially are polyvinyl acetates, polyvinyl chlorides, copolymers of vinyl chloride, and vinyl acetals. The vinyl ester resins were first made in the United States by the Carbide and Carbon Chemicals Corporation. At about the same time Shawinigan Chemical Ltd. introduced polyvinyl acetates in Canada. Of the acetal compounds, the vinyl formal compound has been made by Shawinigan (now part of Monsanto Chemical Co.) since 1938; and the vinyl butyral by Shawinigan, E. I. du Pont de Nemours and Company, and Carbide and Carbon Chemicals Corporation since about the same time. Rubber-like materials from polyvinyl chloride have been developed by the B. F. Goodrich Company, Carbide and Carbon Chemicals Corporation, and General Electric Company.

VINYLIDENE CHLORIDE—Vinylidene chloride resins were introduced in 1939 by the Dow Chemical Company. They have



Courtesy Bakelite Corporation

Above: The original still used by Baekeland, inventor of modern thermosetting plastics, for production of first pilot-plant lots of phenol-formaldehyde resins known as Bakelite. A corner of Baekeland's early laboratory in Yonkers, New York

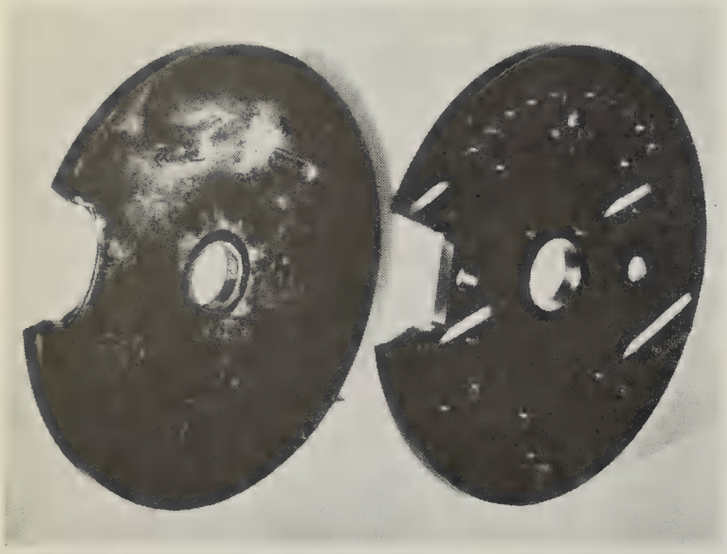
appeared in sheets and extruded tubings and filaments which have been adopted for many applications in the vast war program.

STYRENE—Polystyrene is one of the oldest known synthetic resins, but its industrial development in the United States is of comparatively recent date. This may be attributed to disadvantages in the appearance of the early product and in competitive price which delayed its acceptance. The Naugatuck Chemical Company introduced the resin in the United States in 1930. In 1937, the Dow Chemical Company made available a synthetic monomeric styrene of high purity and a corresponding polymeric product in clear, transparent form. These plastics are now also supplied by several other companies. The most significant properties of polystyrene are its low power factor and practically zero water absorption. In addition, it is resistant to moderately strong acids, alkalies, and alcohol.

ACRYLIC—The acrylic type of resin is another example of a synthetic plastics which has been known to chemists for many years but which has become available in quantity

only through an intensive development characteristic of present-day industrial research. These resins were first prepared in this country industrially by the Rohm and Haas Company in 1931. Methyl methacrylate resin was introduced on the market in transparent sheet form in 1936 by this same company, and the company's molding compound became available in 1939. In 1937 the material was marketed by E. I. du Pont de Nemours and Company in both sheets and powder.

The optical properties of cast methyl methacrylate sheets



Left: Controller plate from one of the first molds made about 1909 for Bakelite molding. Right: Another plate from a mold made in 1916. Part from the 1916 mold shows improvement in finish produced by this mold over that made in the 1909 mold. The older mold, however, is still in service

make this material exceptionally well adapted to the gun turrets, cockpit enclosures, and other structural parts of airplanes.

ETHYL CELLULOSE—The first patents granted in the United States on ethyl cellulose, went to Lilienfeld—in 1916 for the preparation of the material and in 1917 for its use as a plastics material. Commercial production was initiated by the Hercules Powder Company in 1935 and other companies now have formulations of this material. The material's chief applications to date have been in protective coatings, adhesives, paper and fabric coatings, and wire insulation.

CELLULOSE ACETATE BUTYRATE—The successful production of a plastics material from the action of acetic acid on cellulose inevitably led to research on similar treatment of cellulose with higher aliphatic acids. It was found that best results are obtainable from mixtures of the acetate with esters of the higher homologs, and an early patent for the preparation of a cellulose acetate propionate and a cellulose acetate butyrate was granted to Clark and Malm in 1932. Hercules Powder Company introduced the latter product to the American market in 1932, and, in collaboration with the Tennessee Eastman Corporation, introduced the propionate mixture in 1937. Tennessee Eastman Corporation also introduced the acetobutyrate as a molding composition in 1938.

COUMARONE-INDENE—The development of coumarone-indene resins, used as binders, received a great impetus in the establishing of the American coal-tar industry during and following World War I. Manufacture was started by the Barrett Company (now the Barrett Division of Allied Chemical and Dye Corporation) in 1919 and by the Neville Company in 1929.

REGENERATED CELLULOSE—In addition to the work on the creation of new compounds, investigations were made on the conversion of solid cellulose into liquid chemical compounds, and the later reconversion of these solids in the form of films and filaments. Although the process of manufacturing this material was perfected by 1912, Cellophane was not launched on the American market by E. I. du Pont de Nemours and Company until 1924. A similar wrapping material is now made by the Sylvania Industrial Corporation.

ALKYD RESINS—The development of alkyd resins came about through the investigation of all possibilities for coatings, to meet the ever-increasing demands of the automotive industry. After a period of intensive research, the General Electric Company, introduced alkyd resins in 1926. At first, large quantities of the alkyd resins were introduced into the cellulose nitrate lacquers to obtain better adhesion and diminish the porosity of the cellulose nitrate films. During the past decade, a number of companies have entered the market.

PLASTICS FROM WOOD—The utilization of waste wood and sawdust for the production of molding compositions has been the objective of a considerable number of investigators for the past ten years. In 1937, the first lignin plastic in sheet form for laminating was manufactured by the Masonite Corporation, and the development of lignin molding compositions of both the thermoplastic type for injection and impact molding and the thermosetting type involving curing reactions in the mold was announced in 1939 by the Marathon Chemical Company.

Under the more familiar name of veneer, plywood has been well known and used for many purposes since the days of the ancient Egyptians. The use of resins as adhesives to hold together the thin layers of wood was first noted about 1920, but they did not become commercially available until about 1930.

High-density plywoods have been on the market for several years following a period of successful application in Europe.

NYLON—One of Du Pont's latest developments is nylon which was introduced in 1938 for bristles in tooth brushes and later successfully adapted to surgical sutures, synthetic fabrics, and women's hosiery.

ALLYL RESINS—The resins based upon allyl alcohol are new materials which satisfy the demand for resins possessing some of the properties of thermoplastics and the chemical resistance of the thermosetting materials. With the introduction of this type of compound considerable impetus has been lent to the field of manufacture of resinous compositions, particularly by casting techniques.

POLYETHYLENE—In commercial production in this country since 1943, polyethylene is used practically exclusively for the insulation of high-frequency wire and cable. Reports on its characteristics by Du Pont and the Bakelite Corporation have indicated that many other important uses may be expected from its combination of flexibility and toughness over a wide range of temperatures, low water absorption and impermeability to moisture, chemical inertness, and excellent electrical properties.

SILICONES—Organo-silicone oxides include fluids for use over a wide temperature range with little change in viscosity, chemically resistant greases, insulating resins, high-temperature lubricants, and heat-resistant silicone rubbers. Information regarding their properties and wartime uses have only recently been made public by the Dow Chemical Company and the General Electric Company.

THE FUTURE—At present, the panorama of materials development is one of steady growth of the already familiar products rather than the introduction of numerous radically new types of compounds. An estimate of the individual-material production figures gives a total of about 790 million pounds as the current annual rate of production of all major classes of plastics and resins. Of this, approximately 413 million pounds may be considered as structural or rigid plastics. These are the plastics which, we are told, will find themselves in post-war competition with light metals. In some isolated cases there may be some competition. It will, however, in all probability be only temporary; and each material will ultimately find its own sphere of usefulness. Wise designers will take advantage of the divergent properties of metals and plastics, and will combine them so that they are complimentary instead of competitive.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

MOLDING COMPOUNDS



LOOKING FOR A LONG-DISTANCE OPERATOR?

The unusual impact strength of the Durez phenolic casing is what makes this telephone a real long-distance operator. Few people realize what a terrific beating the average telephone takes even under the most favorable circumstances. However, the rigid requirements of this telephone for impact strength, dielectric strength, and moldability were more than met by the Durez phenolic molding compound selected. Durez plastics provide the design engineer with such desirable properties (in addition to those mentioned above) as heat resistance, moisture resistance, highest dimensional stability, and resistance to mild acids and alkalies. Add to the product versatility of Durez phenolics the many new molding methods and processes developed by your custom molder, and you can appreciate the almost unlimited scope which is available to progressive manufacturers with a "weather-eye" on post-victory markets.

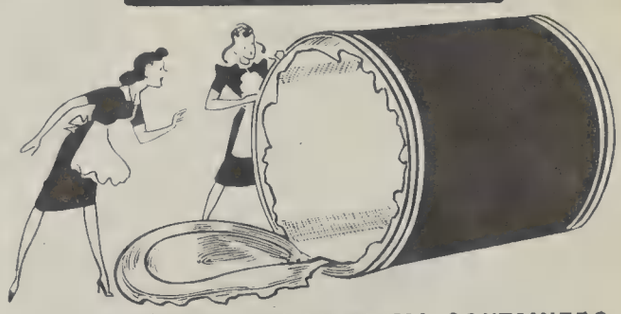
INDUSTRIAL RESINS



GETTING HIT WITH A HAMMER CAN NOW BE A PLEASURE

Safety helmets that are said to possess almost double the impact strength of laminated headgear formerly produced are now being low-pressure molded from Durez-resin-impregnated duck. The use of Durez phenolic resins for impregnating such materials as duck, paper, or sheeting is now being practiced successfully on such a wide scale that the design engineer has a myriad of proven applications available for study to assist him in selecting the resin that precisely fits his job.

OIL SOLUBLE RESINS



THE INSIDE STORY ON METAL CONTAINERS

Durez phenolic resins used as sanitary coatings on the inside of food containers are resistant to fruit acids, wines and beer . . . are odorless and non-toxic. The versatile properties which Durez phenolic resins impart to paints, varnishes, enamels, lacquers, and inks, make them of unusual value to the progressive manufacturer with post-victory markets in view.

You are a scientist. This means that you are a man of imagination . . . a man who knows how to develop ideas. The above at-a-glance picture of Durez operations should serve as a ready reminder to you of the versatility of phenolic resins and molding compounds . . . of the unusual value which the phenolics offer to the developer of imaginative ideas. For the past quarter century, Durez has specialized in the production of phenolics so that, today, Durez resins and molding compounds are leaders in their respective fields. Combine these facts with the background which Durez technicians have acquired through active participation in the successful development of many and varied products—and you can readily understand their worth to you. The services of the Durez staff are available at all times towards aiding the successful development of practical industrial products. Durez Plastics & Chemicals, Inc., 525 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

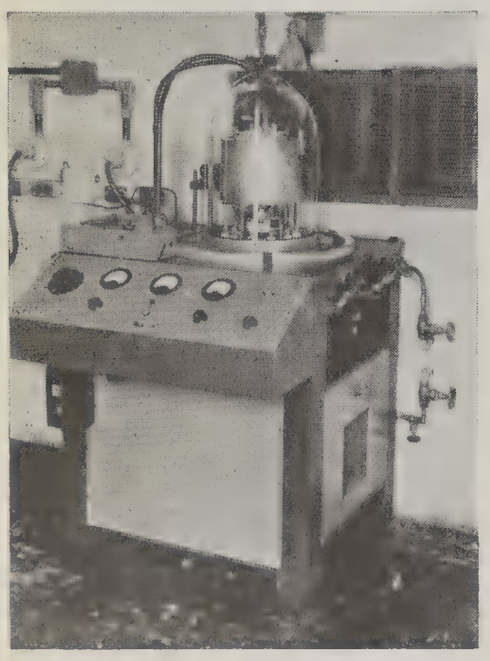
Working For Industry

In High-Frequency Heating, in Production Control and Regulation, in Lens Coating Processes, in Measurement and Analysis, in Liquid Level Control, and in a Wide Variety of Other Applications, Electronics has Established its Value as a Working Tool for the Chemical Industry

By JOHN MARKUS
Associate Editor, *Electronics*

A LARGE number of chemical applications of electronics are of a measuring nature. Examples of this are controlling combustion, liquid levels, temperature, and pressure; quantitative determinations of the conductivity of solutions, dielectric properties, humidity, transparency, color, and turbidity; also electron diffraction, x-ray diffraction, and mass spectrometer analyses.

PRODUCTION HEATING—The use of high-frequency methods for heating dielectric materials involved in chemical processes has in the past proceeded mostly by a process of trial and error. Actually, however, the amount of heat produced in a particular load of material is directly related to two factors —the dielectric constant and the dissipation factor—both of which are functions of frequency, temperature, and impurities. The product of these is called the loss factor, and determines the amount of heating for a given voltage and frequency. The higher the values of frequency, voltage, and loss factor, the greater is the heating effect. The limiting factor has been the development of oscillators with appreciable output at higher frequencies.



During the process of coating lenses with magnesium fluoride to reduce surface reflection, a phototube and an exciter lamp (mounted above the bell jar) measure the diminishing intensity of light reflected from a test lens to determine when the proper coating thickness has been reached

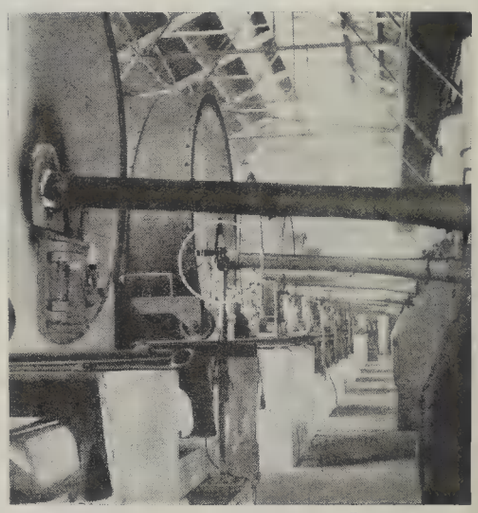
War-time developments in radar oscillators point the way to ultra-high-frequency oscillators with considerable power output.

Dielectric measurements of three cellulosic fillers—cotton duck, kraft paper, and alpha paper—have revealed several factors significant in dielectric heating. Simulating production conditions, without purifying the samples, plastics laminates were made by impregnating the materials with resins. The tests showed that relative humidity, fillers, and impurities have pronounced effects on the heating while the resins have negligible influence. Relative humidity has a very pronounced effect, increasing the rate of heating, particularly above 50-percent relative humidity. The effect is more pronounced at high frequencies, and cotton duck is more affected than the wood pulp papers.

Fillers and impurities are often more important than the main ingredients insofar as dielectric heating is concerned. Porous materials are more affected by moisture than homogeneous solids. The air gap between electrodes also influences heating since an increased gap reduces the field strength in the material. Irregularities in the thickness of the material result in irregular heating unless compensation is made by adjusting the air gap so that it is greater in the region where the material is thinner. Finally, the distance between electrodes may be critical at certain frequencies. Careful consideration of these factors in dielectric heating is an important step in the quantitative determination of the applicability of dielectric heating in a given production problem.

NEW MATERIALS—The chemist has played an important part in the recent advances in radar, radio, and television. The search for new insulating materials, for example, has culminated in commercial production of a new family of materials called silicones.

The silicones, in a sense, combine mineral and organic plastics. They fill



Photoelectric pyrometers provide automatic temperature control of ten cement kilns. The General Electric phototube in the circle is aimed at a clinker zone of high temperature

in the previously unexplored territory between glass—a mineral plastics—and the hydrocarbon compounds which make organic plastics. Processed into resins and bonded with spun glass, asbestos, or mica, they produce an insulating material almost indestructible by heat.

An entirely different kind of material, colloidal graphite, has been another chemical contribution to electronics. Aircraft radio sets, according to Acheson Colloids Corporation, will work more quietly and efficiently if the grids and plates of the tubes are treated with this product.

LENS COATING—An electronically controlled process is now being used to coat lenses used in military and naval optical equipment with special chemical films which increase the transparency of the glass by reducing its tendency to reflect light. Electronic equipment determines the critical thickness of the films as well as the degree of vacuum which has a bearing on their hardness.

The low-reflection coating is applied by evaporating chemically pure mag-

Typical Electronic Applications in Use Today in the Chemical Industry

Purification of carbon dioxide by electrostatic precipitation

Recovery of acid and catalyst used in petroleum refining, by electrostatic precipitation

Use of electrostatic precipitation to remove water particles from gases used in production of petrolatums, lube oils, petroleum sulfonate, and so on

Maintenance of liquid level in vacuum crystallizers by regulating outflow with electronically controlled valves, in a plant that produces alumina and potassium sulfate

Controlling the level of damp common salt in a bin

Electrode-type electronic control of levels of liquids and dry materials in a plant making industrial chemicals

Motor speed control in chemicals mixing equipment

Controlling the entire heat cycle on a plastics molding press; a single temperature control unit initiates all valving action of steam, water, air, and hydraulic pressures

Temperature control with thyratrons, phototubes, and amplifiers monitoring the processing of cement products by the color of the flame

Chemical analysis by colorimeter of drugs, cosmetics, soaps, glycerine, chemical and ceramic raw materials, petroleum products, and so on.

Electronic titration control in manufacture of chemicals

Photoelectric weighing for automatic filling of containers to predetermined levels or weights

Photoelectric weighing apparatus for automatically weighing powder used in making hard rubber and plastics goods

Regulating specific gravity of muriatic acid by electronically controlling the reverse-acting valve on water feed

Use of phototube to measure amount of nitrate in hopper in manufacture of fertilizer by a meat packer

Feeder control on a roller mill producing high-grade talcs

Electric ear serving as milling control in production of chemical and ceramic raw materials

Electronic conductivity meter for control of water flow through heat exchangers in production of aluminum and potassium sulfate

Use of ultra-violet lamps for bactericidal action in a plant turning out butanol, acetone, methanol, butyl acetate, and ethyl acetate

Use of ultra-violet for bacteria control in a tire and rubber plant

Automatic pH control of acid feed to treated water used in an explosives plant

Automatic photoelectric equipment to control the gloss and finish of the paper output of supercalenders

Speed and regulator controls for coating machines used in production of photographic film and paper

Automatic starting and stopping of conveyors and machinery in a plant making chemicals and related products

Photoelectric turbidity control in manufacture of pharmaceuticals, plastics, bicarbonate of soda, sodium hydroxide, chlorine, lime, Portland cement, roasted dolemite, and so on

Detection of low and empty bottles on production lines in a plant producing drugs and cosmetics

Geiger-Müller counter for potassium determination by its own radioactivity

Fluoro-photometers for checking and analysis of product quality in plants producing pharmaceuticals, flour and feeds, vitamin-D products, butanol, acetone, ethanol, and methanol

Flame failure control by conduction and by light of flame, in plant making heavy chemicals

Overflow alarm system on dentrifice storage tank

Explosion meter for sounding alarm when hydrocarbon vapors escape into room in a petroleum products plant

Photoelectric control of weighing to provide automatic cutoff of cylinders being filled with compressed gas, in a plant making organic chemicals

Colorimeter for vitamin analysis of cereal foods

Colorimeter for color-testing soft brown sugars

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nesium fluoride powder in a vacuum bell jar, so as to bring the resulting vapor into contact with the lens surfaces under low-pressure conditions. A baking operation is carried on within the jar by means of radiant heaters.

As developed by RCA, the process employs a conventional electron multiplier phototube to measure the diminishing amount of reflected light from the lens. This enables the operator to stop the coating operation when exactly the proper thickness of film—about five millionths of an inch—has been established.

Vacuum gages, electronic amplifiers, and meters are used to determine quickly and accurately whether the degree of vacuum within the jar is such as to produce a coating of satisfactory hardness.

Although the forming of the magnesium fluoride film is carried out in a vacuum, it is imperative that the room in which the lenses are washed and prepared for coating be free of dirt and dust—a speck of dust could create an image behind which an enemy ship or factory might hide while the periscope or bombsight is in use. Air entering the coating room is kept free of dirt by an electronic air cleaner, the Westinghouse Precipitron.

LIQUID LEVELS—Chemical industries are frequently concerned with the sensing of liquid levels in storage tanks. These tanks may provide reserve storage or may be a portion of a complete processing plant in which the levels vary constantly as the product is added to or subtracted from the tanks. The materials encountered may range from hydrous and anhydrous mixtures and compounds to highly corrosive fluids such as acids and alkalis.



Phosphors that give off the light from fluorescent tubes are mixed in the tank in the foreground. The phosphor mix is forced into three tubes at a time, the excess draining back into the tank for immediate re-use

A float mechanism introduced into the storage container has been the conventional solution to the liquid level measurement and control problem. A shaft and stuffing box, a diaphragm seal, or a pneumatic or hydraulic transmission system is then used to bring the resulting level indication out of the tank where it in turn controls the position of a remotely situated valve or an indicating or recording mechanism.

These essentially mechanical devices are subject to many types of trouble because they are continuously exposed to unfavorable operating conditions such as chemical attack, mechanical erosion and friction, high temperature, and high pressure. Reliability can often be secured by constructing the float mechanisms with extreme care and attention to detail in view of the conditions under which they operate, but cost and upkeep may then become disproportionately high.

The chemicals usually stored in a liquid or solid state may be electrolytes (having electrical conducting or semiconducting properties) or dielectrics (having electrical insulating properties). By allowing these chemicals to become a portion of the structure of an electrical capacitor, they can be made to produce a change in capaci-

tance large enough to affect an electronic oscillator circuit and thereby actuate an indicating device or operate a relay in an automatic control circuit. With such a relay arrangement to open or close an electromagnetic valve or to start or stop an electric pump, the chemical in the tank may be maintained automatically and accurately at any desired level.

ELECTRONIC SENSING—An electronic level-sensing capacitor may consist of a pair of semi-cylindrical metal segments clamped around the outside of a glass manometer column that is indicating liquid level by manometric means, or may be a capacitor element mounted with a nonmetallic, leakproof protecting tube that is mechanically designed for immersion in storage containers under conditions of high pressure and/or temperature.

The manometric capacitor arrangement will work for both dielectric and electrolyte liquids in the manometer. If the liquid is an electrolytic (conductor), the capacitance of the sensing capacitor will be a minimum when there is no liquid between the plates, and the increase in this capacitance as liquid level rises will be a direct function of the height of the liquid between the plates.

Many electrolytes may leave a conducting film on the interior surface of the manometer column as the liquid level drops, and this may cause error. An agent must then be applied to the interior surface of the column to prevent this wetting action and film formation.

With liquid dielectrics (such as some types of oils) in the manometric arrangement, and with all types of liquids used with immersion capacitors, the capacitance change will also occur between minimum and maximum limits and will again be a function of the height of liquid in the area of the sensing plates.

The oscillator relay mechanism developed by Wheelco Instrument Company is ideally suited for sensing the change in capacitance of level-sensing capacitors. It consists essentially of a vacuum tube connected as an oscillator, with a relay in the plate circuits and the level-sensing capacitor connected to the tuned grid circuit. With proper adjustment of the circuit, a change in liquid level can be made to start or stop the oscillator and open or close the relay, as required to provide the desired type of automatic control.

Capacitive level-sensing systems are also used to measure and control the position of the interface boundary between two liquids of differing density and differing dielectric and conductive properties. Examples of this in the chemical industry are sensing of the interface between gasoline and water in underground reservoirs and sensing the interface position between an oil and an alcohol.

The movement of the interface over the sensing area of the manometric or immersion capacitor produces an appreciable change of capacitance. The greater the difference in the electrical properties of the two liquids, the greater will be the change in capacitance and the more accurate will be the control of interface level, other conditions being equal.

Because of the extremely low radio-frequency energies present in a level-sensing capacitor that forms a portion of the grid resonant circuit of an oscillator, fracture of the protecting tube does not expose flammable or explosive vapors to possibilities of ignition by sparking.

VULCANIZING—In electronic vulcanization of rubber, high-frequency oscillation shakes the molecules of rubber and sulfur millions of times a second, creating uniform heat throughout the product being vulcanized in a fraction of the time required when steam is used.

Sponge rubber mattresses and pads have been cured by this electronic method in one eighth the time needed by conventional processes. Tires, molded rubber goods, brake bands, and many other products can also be cured much more rapidly by electronics, with decided improvements in the products obtained. The same electronic heating removes difficulties in the molding of thick plastics products, by providing quick and uniform heating of plastics preforms so that the material flows readily into all parts of the mold when placed in the molding press.

* * *

CAMERA SHUTTER

Tripped by Light From Flash Bomb

An electronic control that automatically synchronizes a new type aircraft camera shutter with the bursting of a flash bomb has been developed by General Electric in collaboration with the Folmer Graflex Corporation. The device enables military observers to photograph from high altitudes, and at night, destruction caused by explosives. It takes advantage of the peak illumination of the bomb by beginning an exposure approximately 1/100 of a second after the flash starts. A sensitive photoelectric cell acts on the light impulse coming from the bomb, amplifies the resulting signal, and transforms it into a current to which the shutter responds in less than 1/500 of a second.

EYES AND EARS

Provided by Untiring Electronic Equipment

Two distinctly different types of electronic control units are being used in the mining industry to keep ore crushers operating automatically and continually at the peak load corresponding to maximum efficiency. In one type, a microphone is positioned alongside the crusher and connected to an amplifier and relay combination that controls the conveyor feeding ore into the machine. When the noise level drops to a point indicating that the crusher is running too nearly empty, the electronic ear detects this and calls for ore to be fed in.

In the other type, an electronic eye is used to monitor the amount of electric power drawn by the electric motor which drives the crusher. This power consumption is high when the crusher is fully loaded, and drops as the machine empties. A light source and phototube are mounted over a wattmeter in such a way that the meter pointer interrupts the light beam when the power drops. The phototube feeds an amplifier-relay combination controlling the ore feed mechanism, as before. Electronics thus provides either eyes or ears to do a job that would otherwise require the continuous services of one man in a noisy position not conducive to accurate control of the ore feed.

CARRIER CURRENT

Communication System Used By Power Companies

Utility companies use power-line carrier current to provide a highly reliable type of communication by utilizing the power line for the communication channel.

Improvements and developments such as electronic switching, high-voltage line-coupling equipment, and other refinements, have been given an impetus unequalled in more normal times.

The frequencies usually utilized range from 50 to 150 kilocycles. The radio-frequency energy is confined almost entirely to the wire lines and is not radiated into space as is common in radio broadcasting. This results in greater efficiency and makes it possible to transmit greater disturbances with less energy.

An important application of the power-line carrier system is to provide reliable, high-quality voice communication between such points as generating stations and dispatchers' offices, or between dispatchers' offices of interconnected systems.

ELECTRONIC CASTING

Produces Electrodes of Purified Copper

In the manufacture of metal electrodes for vacuum tubes and x-ray tubes at Machlett Laboratories, a purified copper rod is placed over a mold in a graphite crucible and the whole enclosed within a double-walled quartz-silicon tube. A vacuum of about 10^{-5} mm of mercury is maintained in the tube. A coil surrounding the quartz tube connects to an induction-heating electronic oscillator.

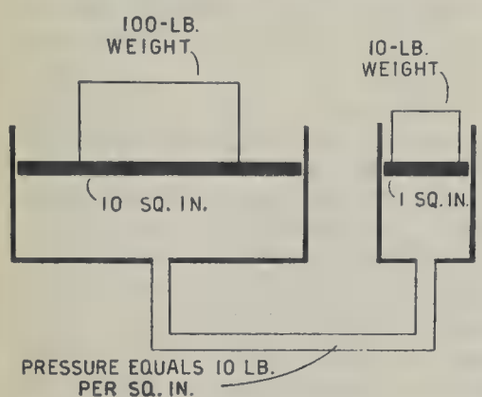
When the oscillator is turned on, the copper melts and flows into the mold. Cooling is precisely controlled by adjusting the position of the heating coil so that crystals form longitudinally for maximum heat transfer under operating conditions. Dimensions of the casting can be held to about 1/10,000 of an inch. No gases can be occluded in the metal of the casting, nor can oxides form.

Oil Pushes Production

Hydraulic Devices Provide Resiliency and Flexibility for the Complex Machine Tools of American Industry. The Oils that are the Lifeblood of These Hydraulic Systems Have Been Treated by Petroleum Refiners to Give Qualities Needed for Long Service Under Difficult Conditions

THE GROWING use throughout industry in recent years of hydraulic applications for the transmission and control of power has created a demand for oils that would bear up under the rigorous burdens imposed by their use in hydraulic systems. To create such specialized oils was a job for the petroleum industry and with characteristic energy and thoroughness it went to work. The research men in the laboratories of America's leading oil refiners took under consideration all the many and complex problems connected with hydraulic fluids. They studied the blue prints of machine-tool designers and the reports of production men in scores of industries using hydraulic-powered machines. With their notebooks in their hands, and their minds as well as their ears and eyes wide open, they paid long visits to the factories and shops where these machines were engaged in actual production runs.

They went back to their laboratories taking similar machines with them.



In this diagram illustrating the hydraulic principle, a ten pound force applied to the one square inch area of the smaller piston is transmitted to act with equal force on each of the ten square inches of the larger piston, creating a pressure of 100 pounds

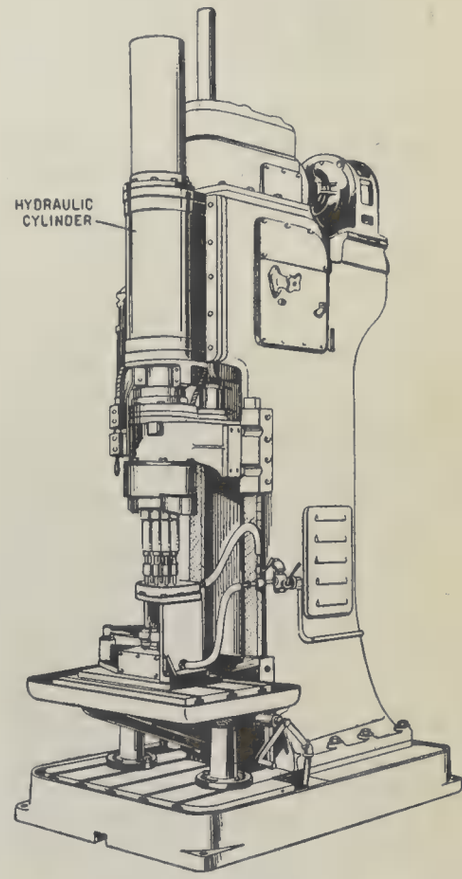
These were set up and put in operation doing the work they were designed to do. The petroleum research men sweated over these machines a long time and they sweated over their laboratory work benches, too. The result was a series of hydraulic oils that function efficiently. But they are not perfect yet. The research men are still working on them and they are making them better and better. Among the oils now widely in use, created especially for hydraulic systems, are the Gargoyle Vacuoline Oils produced by Socony-Vacuum, Texaco's Regal Oils, Houghton's Hydro-Drive, and Shell's Tellus line.

The demand for specialized hydraulic fluids arose because industrial engineers were utilizing to a greater and greater extent the unique advantages of the hydraulic principle in their persistent search for better and more economical ways of actuating and controlling production machines. Outstanding among these advantages is adaptability to complex control with relatively simple mechanisms.

There are other advantages, too. Hydraulic power transmission applied to machine tools permits for example a wide range of cutting speeds, which may be controlled with great accuracy yet changed frequently during operation. It permits a rapid tool approach, but a slow cutting speed when desirable, and then a rapid return at the end of the working stroke. Other important advantages are smooth, vibrationless action that is not greatly affected by load variations; a cushioning effect on tools which helps to extend tool life and improve surface finish; and heavy cutting without disturbances in the operation of the machine. Hydraulics can also be depended upon to provide great pressure when it is needed, with or without motion, and automatic release at overloads as well as automatic shutdown when tools become dull.

Oil is the lifeblood of these hydraulic applications. To grasp how it does its work, it should be recalled that an elementary hydraulic system consists of a piston in a small cylinder which is connected by a pipe to a much larger cylinder fitted with a proportionately larger piston. As every bright schoolboy knows, this arrangement will transmit power because pressure applied to an enclosed fluid is transmitted undiminished throughout the system so as to act equally in all directions.

In other words, if the small piston were one square inch and the large piston 10 square inches in area, a one pound weight placed on the small piston would cause a pressure of one pound per square inch to be transmitted through the piping so as to act on every square inch of the larger piston, producing a pressure of one pound on every square inch of the larger piston or an aggregate pressure of ten pounds. Of course, any movement of the larger piston would be only one tenth of that of the smaller piston.



A multiple speed drill whose feed is controlled by hydraulic pressure

Utilizing this basic principle in hydraulic machine tools, a pump is substituted for the small piston, cylinder, and weight. The pump forces oil into an operating cylinder (corresponding to the large cylinder of the example) thus moving the piston and the attached machine parts. The volume and rate of oil flow into the working cylinder determine the extent as well as the speed of the piston's movement.

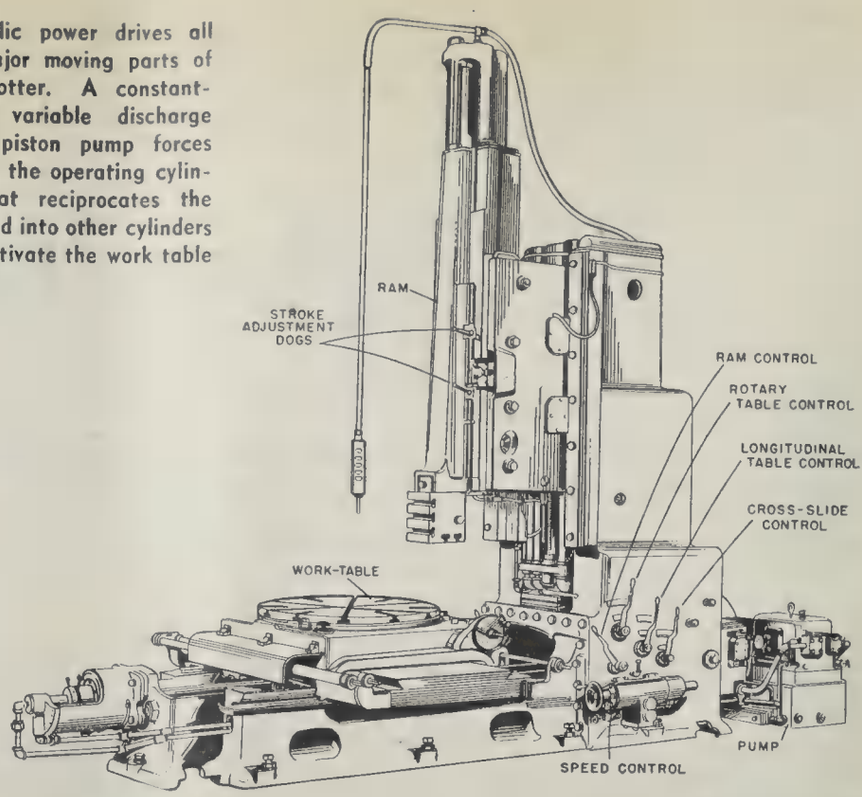
In hydraulic machine tools, two basic methods are used for controlling the flow of oil. The first, the constant-volume system, uses a constant-speed pump, discharging a uniform flow of oil at constant pressure. For this, gear or vane pumps are generally employed. Discharge pressure is held constant by spring-loaded relief valves and

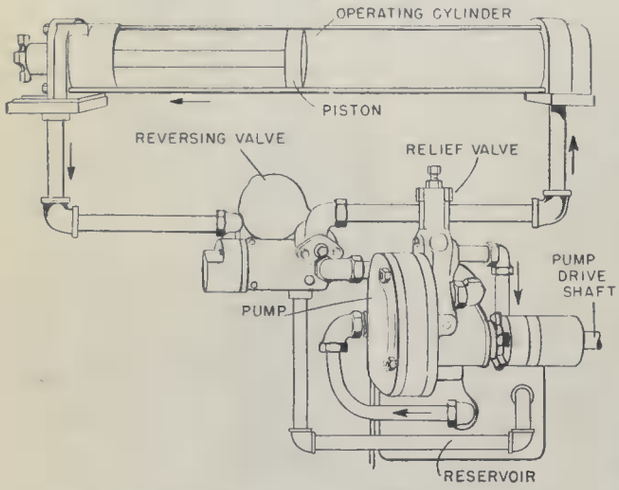
the flow of oil from the pump to the working cylinders is throttled, by-passed, metered, or reversed by means of various other valves.

In the second method, the variable-volume system, a constant speed pump is also used, but the design is such that the rate of discharge can be varied at will from zero to maximum in either direction. Plunger pumps are generally used, in which the length of stroke can be changed to vary the rate and reverse the direction of oil discharge.

Machines usually employ a constant-volume system where the oil pressure is not required to be more than a few hundred pounds per square inch or where variation is small, where small machine parts and work are to be accelerated and decelerated, and where cost of installation is a consideration.

Hydraulic power drives all the major moving parts of this slotter. A constant-speed, variable discharge radial piston pump forces oil into the operating cylinder that reciprocates the ram, and into other cylinders that activate the work table





Here in simplified form are the essential parts of a hydraulic system as applied to a shaper. A pump draws oil from a reservoir and forces it into an operating cylinder where it activates the piston which moves the tool

On the other hand, where pressure is needed in thousands of pounds per square inch and close control is necessary, or where massive machine parts and heavy work must be moved smoothly and without shock, a variable-volume system is generally used.

Many machines use features of both systems, either completely separated to operate different parts of the same machine, or combined for alternate control during varying portions of the operating cycle. Sometimes the systems are combined to work simultaneously with each other. An extremely wide range of combinations is possible. The increasingly complex functions which production men are devising for modern machines leads to the engineering of increasingly complex hydraulic drives for them.

ON MACHINE TOOLS—Typical of machine-tool applications is a hydraulic shaper. Here a constant-discharge gear pump draws oil from a reservoir and moves it under pressure through piping and a reversing valve alternatively to each end of the operating cylinder so as to produce a reciprocating movement of the piston and hence of the shaper head and the cutting tool. A throttling valve controls cutting speed. The extent of stroke is controlled by stops or dogs which actuate the reversing valve when the shaper head reaches the desired limit of travel. The same type of power transmission is used for creating reciprocal motion in other machines, as, for example, surface grinders.

Hydraulic systems of widely varying complexity and design are used on other machines. These include broaches, of which a notable example is a broach for rifling gun barrels; planers; milling machines; drill presses; lathes; boring mills; and honing machines. Other applications are on cylindrical grinders and special purpose grinders. Hydraulic power transmission and control are used to guide and feed the work to the wheel or the wheel to the work, whatever the set-up may be. Punches, presses, and shears also make use of hydraulics to generate the immense pressure needed to force punch, die, or knife through or against the work during a single stroke of the operating ram.

OIL MOVES MACHINES—For all these hydraulic applications the petroleum industry supplies correctly functioning oils, and the problems the refiners overcame in producing them point up the importance of this one phase of the chemical industry. Prime among the essential qualities of good hydraulic oils is correct viscosity. As is shown in Socony-Vacuum's handbook of hydraulic systems, there is always more or less internal leakage, known as slippage, in hydraulic pumps. This lowers the capacity of the pump and increases oil temperature. In variable-stroke piston pumps, moderate slippage can be compensated for by lengthening the stroke of the pistons, but this causes a corresponding increase in the consumption of power.

Where a hydraulic system employs a gear or vane pump, the volume of oil discharged is always greater than the demands of the working cylinders. A by-pass relief valve serves to control the discharge pressure and to divert the excess oil flow back to the reservoir.

Moderate slippage in this type of pump—that is, loss of capacity—consequently does no more than reduce the flow of oil lost through the relief valve. In this case, moderate slippage does not increase power consumption. It does increase, however, the temperature of the oil at the pump. To keep slippage down and to maintain maximum pump capacity with minimum power consumption and low oil temperatures, the viscosity of the oil used should be suited to the particular design of the pump that is employed.

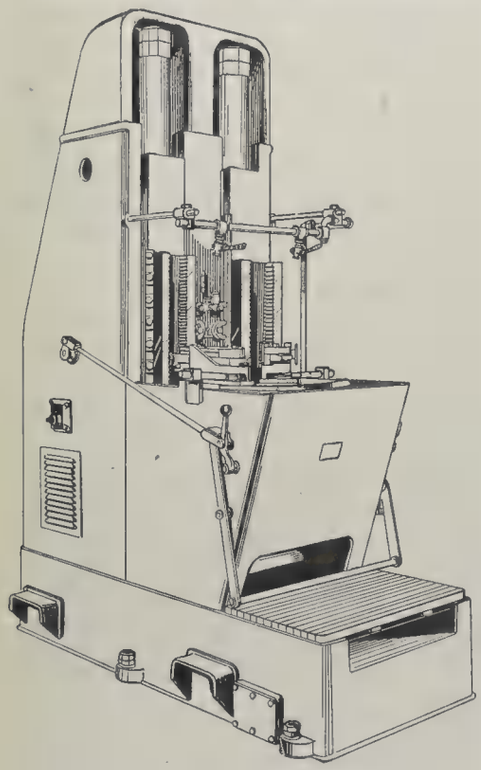
Viscosity has other aspects, too. It must be considered from the viewpoint of the ready flow of oil through the system and the prompt response of valves and other parts. Light-bodied oils assure ready flow and quick response, but their use may cause excessive internal leakage and needless power consumption. Heavier-bodied oils offer a higher resistance to leakage, but are more sluggish. Hence more power is needed to circulate them through pipes, valves, and orifices. The drop in pressure between pumps and working cylinders increases as oil body increases and machine efficiency is consequently reduced.

On the suction side of the pump, under theoretically ideal conditions, the force that causes the oil to flow can be no greater than that exerted by a perfect vacuum, which is approximately 14.7 pounds per square inch. Where the suction area is fixed, the volume of flow to the pump will vary inversely with the body of the oil. If the oil is too heavy in body, the pump will receive an insufficient supply and erratic machine action will be the result. Consequently, all these differing factors must be given due consideration in

selecting an oil of suitable viscosity for the most efficient machine operation.

The temperature of an oil is also an important factor in its viscosity; the temperature under which the oil will be used must be considered in selecting the correct viscosity for best service. In systems where a variable discharge pump repeatedly reverses its suction and discharge, the same oil may pass back and forth through the pump and only a small volume of oil is drawn from or discharged into the reservoir. In such cases the reservoir temperature *may not* represent the true operating temperature of the oil; the crucial factor, then, is the temperature at the pump.

A hydraulic oil that would maintain the same viscosity at all temperatures



The vertical rams and the work table on this duplex vertical broaching machine are all hydraulically operated

would be highly desirable. Such an oil would be just as prompt in its action when the machine was first started as it would be after a warming-up period. As yet, no such oil is available, although some oils have a minimum viscosity change over a wide range of temperatures. The use of such oils cuts down the period of sluggish action, lowers power consumption, and reduces the non-productive time needed for warming up the machine.

LUBRICATING QUALITIES—In addition to transmitting pressure, hydraulic oils must also lubricate the moving parts of pumps, cylinders, and valves. In fact, on some machine tools, oil is bled from the hydraulic system to lubricate the ways. To prevent excessive wear, particularly where fluid pressures are high, good hydraulic oils must provide strong lubricating films that resist the pressure and wiping action between moving parts at whatever operating temperatures the machines may develop. A lubricating film under these conditions must possess unusual strength since it is only microscopic in thickness.

Deficiencies in film strength cause excessive wear and unnecessary power consumption. Wear inside a machine increases internal clearances and therefore internal leakage. Wear at glands and stuffing boxes increases external leakage. When wear occurs, the metallic contact between the moving parts develops excessive frictional heat, increasing the oil temperature and consequently thinning the oil. Thinner oil still further increases internal leakage and power consumption, and impairs as well the value of the oil as a lubricant by reducing its load-carrying capacity. Furthermore, lack of film strength, in some machines, may result in piston, table, and slide chatter, which in turn causes inaccurate and imperfectly finished work. In all machines, deficient lubrication causes excessive maintenance costs and premature replacement of expensive parts.

Another necessary quality of good hydraulic oils is demulsibility; in other words, the ability of oil to resist emulsification when mixed with water. This quality is important because moisture is often present in the hydraulic system of a machine. It may result from leakage of water-soluble cutting fluid into the system, or it may arise from condensation of the moisture in the atmosphere as air surges in and out of the reservoir breather pipe. When water mixes with some oils, permanent emulsions are formed. These may be of thin and slimy nature, or of a sticky, pasty consistency, or may be heavy gummed deposits, depending upon operating conditions. Such emulsions interfere badly with the correct functioning of valves and other precisely adjusted parts.

Resistance to emulsification in an oil depends upon its ability to separate readily from moisture so that water which enters the system can settle to the bottom of the reservoir and not be circulated with the oil.

CHEMICAL STABILITY—The most important overall qualification of serviceable hydraulic oils is chemical stability. Constant churning and circulation in the presence of air tends to cause chemical changes in hydraulic oils. If they cannot resist this tendency, oxidation occurs and the oils sooner or later thicken and become sluggish in service, retarding the operating cycle and slowing down production. Sludge and gummy deposits form, interfering with reliable action of the machine. Hence the oil which resists chemical change and retains its original character for the longest time will give the best service.

High operating temperatures tend to accelerate the oxidizing process. Therefore the lower the operating temperatures can be kept, the less will be the tendency toward destructive oxidation. In most hydraulic systems, operating temperatures do not exceed 130 degrees, Fahrenheit. Where oil coolers are used the temperatures may be kept within relatively narrow limits. Of course, operating temperatures vary according to the design of the machine and the kind of work being performed. In some machines, the circulating oil is discharged for extended periods through a relief valve. Such conditions may increase the temperature of the oil in the working part of the system beyond 130 degrees, Fahrenheit. In some cases, it may go as high as 200 degrees, while exceptional cases have been noted where the oil has become heated as high as 280 degrees, Fahrenheit. Under these high temperatures, superlative chemical stability is needed to guard the oils against oxidation and the formation of gummy deposits.

Hydraulic applications in machine tools are bound to grow in the years following the war. Here is an expanding market for the petroleum industry where quality is primary and price secondary as far as the consumer is concerned. To date, the industry has kept pace with the specifications of mechanical engineers and manufacturers of hydraulic equipment. In doing so it has fulfilled the immensely increased demand for hydraulic oils stimulated by the urgencies of war production. But its work along these lines is by no means finished. A significant portion of the future achievements of the petroleum industry, once peace returns, will lie in the improvement of hydraulic oils for use in the machines that cut, stamp, grind, and drill the useful things men and women everywhere want in order to live a more abundant life.

NEW ENGINE

Uses a Variety of Fuels Without Sparking Devices

A development in Diesel engines, which will enable the operator to use either gas or oil as fuel without any electrical sparking device, and which will cut fuel consumption of gas engines as much as 25 percent, has been announced by Ralph L. Boyer, chief engineer of The Cooper-Bessemer Corporation.

Experimentation which began in 1928, Mr. Boyer said, recently has been rewarded by the successful operation of a natural gas engine on the Diesel principle. This enables the unit to operate on a wide variety of fuels including fuel oil, natural gas, manufactured and coke oven gases, sewage gas, and refinery by-products. According to Mr. Boyer, conversion from liquid to gas fuel is as simple as the closing of one valve and the opening of another with the engine operating continuously at full load. Although conversion from one fuel to another has been possible in the past, it has always been necessary to shut down and exchange major or minor parts of the engine.

The new principle, it is said, will enable the engine to have the same fuel economy regardless of the type of fuel used.

Aide To Aviation

One Chemical Plant Alone Produces 80 Chemicals Used in the B-29. This Fact Brings Home the Close Relationship between Chemical Industry and the Mass Manufacture of Airplanes, Both Those Used Today for War and Those that Will Fill the Skies in the Coming Days of Peace

CHEMISTRY supplies to the science of aeronautics many of the ingredients essential to large-scale aviation as it exists today. Leaving out of the picture the well-known subject of fuels, it can be said that one of the most striking as well as most recent of chemistry's contributions is the use of glass-reinforced plastics. Before the advent of Fiberglas, plastics had proved eminently satisfactory in many non-structural parts of the airplane, but had served less frequently for structural parts; airplane designers raised objection to the low specific strength-weight ratio of plastics. The use of glass-reinforced low-pressure resins seemed to remove this objection, and officers of Wright Field, with Colonel Paul H. Kemmer in the lead, initiated a research project in co-operation with Owens-Corning-Fiberglas Corporation, which, in turn, sought the help of seven leading manufacturers of thermosetting resins. Glass was the common denominator in the use of resins with such famous trade names as Plaskon, Laminak, and so on. Combinations of resin and glass fiber were prepared in the form of cross-laminated sheets. With specific gravities between 1.69 and 1.81, tensile strengths of over 50,000 pounds per square inch were obtained, and flexural values ran higher still, up to 84,600 pounds per square inch.

To enormous strength and low density were joined hardness and resistance to abrasion, impact, flame, and moisture. Thanks to the cross-lamination, a fair balance of strength in all directions of the material was obtained. Another advantage of Fiberglas, with its copolymer resins, is that it lends itself to low-pressure molding at moderate temperature, thus avoiding complicated and expensive equipment.

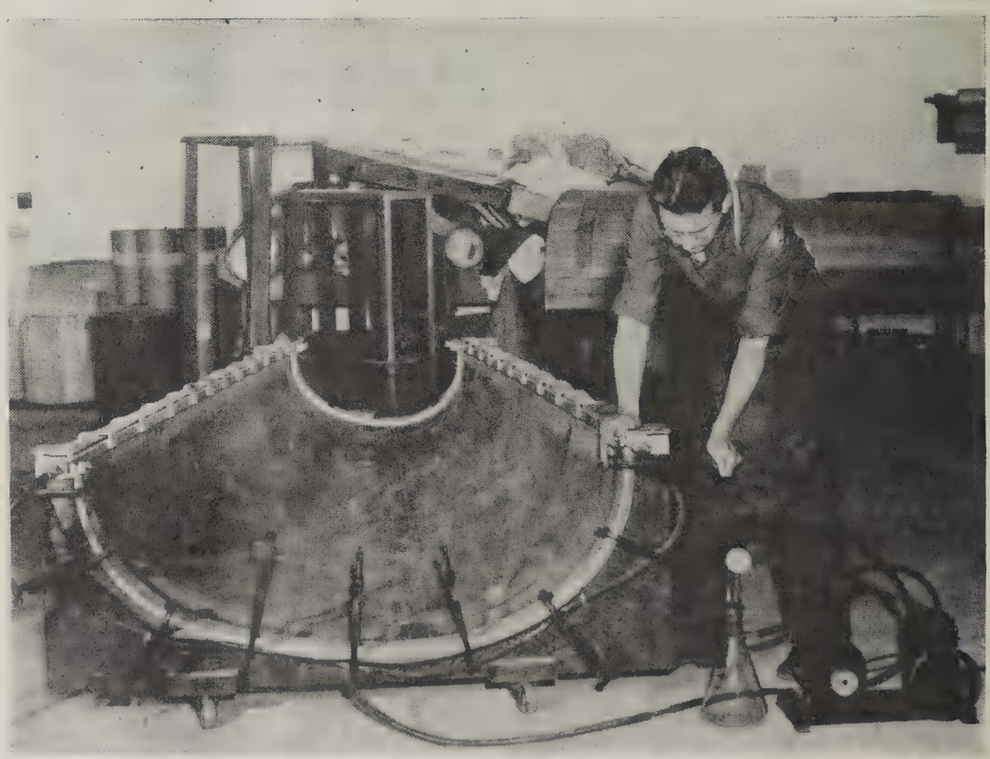
The next step in the program was the development of sandwich construction in which multi-plies of the glass-reinforced plastics are used for faces, with a balsawood core having grain parallel to the faces. The advantage of such sandwich construction is that, with the heavy fibers separated by the light core, far greater local strength against buckling is secured. Sandwich construction is a valuable addition to aviation technology and is being applied to other materials besides Fiberglas.

PLASTICS AIRPLANES—When this new structural material had been perfected, Wright Field decided to see what could be done in duplicating the aluminum fuselage of a BT-15 training airplane with the aid of the Fiberglas-balsa sandwich. A molding technique was also developed in which glass cloth is laid upon an impregnating table, and laminating resin is applied uniformly to the cloth by the use of squeezes. Then the material is transferred to the male mandrel where the five plies comprising the outer face of a fuselage skin are carefully trimmed. The face plies are then transferred to a female mandrel.

Then the prefabricated balsa core is placed in position, and on top of this the inner five plies. A rubber blanket is placed over this assembly and sealed on the edges. By means of a small pump a partial vacuum is drawn between the blanket and mold, with inserts in place. Once this has been done, the assembly is ready to be cured. The mold, mounted on wheels, is rolled into an oven where it is subjected to a temperature of 220 degrees, Fahrenheit, for a period of three hours. Thereafter, the molded section is withdrawn and its rough edges trimmed off. To join the two halves of a fuselage, a spline is inserted into the core and glued with a cold-setting resin glue. Bulkheads are assembled and glued into place, and the completed fuselage is ready for assembly.

The fuselage was subjected to destructive tests in direct comparison with a 24ST aluminum fuselage. With a weight only a few pounds greater than that of the metal fuselage, the destructive load for the Fiberglas-balsa fuselage was increased nearly 80 percent. The reasons for this excellent result lay partly in the greater specific strength of the Fiberglas and partly in the sandwich construction.

There are other important applications of Fiberglas in airplane construction. Light, flexible sheets of resin-impregnated Fiberglas cloth are used as protective linings in fuel-cell cavities built into the wings of a Boeing Superfortress. Because the glass sheets possess high impact strength, they prevent "flowering" of the metal walls of the fuel cell if struck by a bullet. Thus they

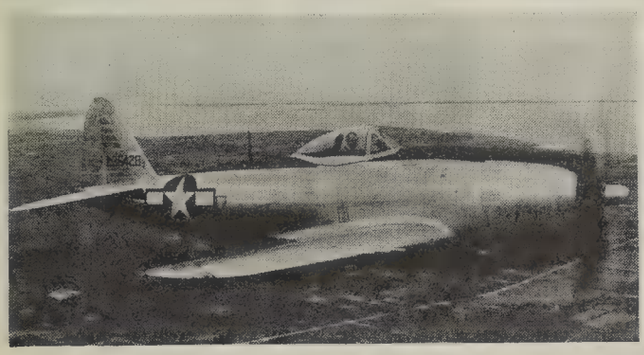


After the elements of a Fiberglas-balsa fuselage are assembled in the female mandrel and sealed with a rubber blanket, a partial vacuum is applied by pump at right

safeguard the rubber fuel cell against protrusion of the jagged petals of such "flowers" into its wall—and therefore do not prevent the self-sealing material from closing the hole.

SAFETY IN OIL LINES—A contrast to Fiberglas in both composition and use is compar, another plastics that serves aviation. It was developed by Resistoflex Corporation and the name was derived from the words "Compounded Modified Polyvinyl Alcohol Resin." These compounds and modifications take on some plastics- and some rubber-like properties during the compounding and processing, but all appear to be flexible, tough, and resistant to abrasion.

Some types of the compar group have exceptionally low permeability to gases, others freedom from aging or oxidation, while still others retain their valuable properties through the wide temperature range of — 70 to + 300 degrees, Fahrenheit. All have a high degree of polymerization, high molecular weight, and low specific gravity. Perhaps the outstanding characteristic is resistance to the action of gasoline, oils, and most of the organic solvents. Tensile strength is high. The production of compar includes some methods common to the plastics industry and some to the manufacture of rubber. It is milled like rubber, for example, but transformation into finished products is accomplished by extrusion or molding.



The bubble shaped canopy used on this Thunderbolt gives unobstructed vision in all directions. The canopy is fabricated of one piece of Plexiglas, requires no metal framework, and is light in weight

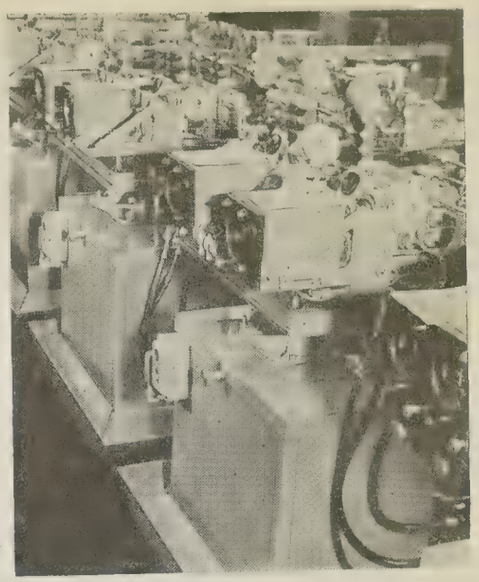
Some of the aircraft applications in which compar has been employed are of great interest. For example, the Sperry Gyropilot is an essential element of long-range flight and of precision bombing. In production testing, the Gyropilot with its various hydraulic lines must be submitted to rolling, pitching, and yawing motions of great violence, and of 'round-the-clock operation on the vibrating stands. The lines have to be oil-proof, flexible, capable of indefinite service, and resistant to "hammer" or suddenly applied hydraulic pressures of between 150 and 200 pounds per square inch. The short flexible lines have to withstand constant coupling and uncoupling and remain flexible. Lines must be bent on a five-inch radius to permit cleaning of machines and to make certain connections at sharp angles. The hydraulic fluid must not permeate the walls of the tube. The compar lines have met all these requirements and on the test stands a single line has served for five years without showing any deterioration.

An equally important application of this plastics lies in maintenance work. After Pearl Harbor, it became necessary to apply camouflage finish to the upper and lower fabric-covered surfaces of Boeing Clippers used by Pan American Airways, instead of the aluminized dope used during peace-time. Operational difficulties developed because the camouflage finishes caused rapid deterioration of doped surfaces, particularly in tropical climates, and necessitated frequent replacements. There was delay in replacement because doping could not be undertaken during humid weather. Then a new technique was developed, "hot doping," in which heating the viscous colloidal dope to 175 degrees, Fahrenheit, lowered its viscosity sufficiently to permit of spraying with a standard spray gun. Heating the dope, instead of reducing its viscosity with thinners, allowed the deposit of more solid material in each coating, so that four or five coats instead of eleven became sufficient. But then another difficulty arose: no ordinary hose could stand the organic chemicals employed at elevated temperatures. Compar hose, however, came to the rescue, and the hot doping of the control surfaces became commonplace.

Recent advances in aircraft engine design involving the use of fuels with an increasingly high "aromatic" content, have shown the need of fuel lines that are resistant to benzol, toluol, xylol, or other aromatic fractions. Here the problem has been solved by the use of hose of varied types, with cores made of vinyl plastic which neither breaks down nor sloughs under the action of lubricating oils or fuels. These lines are widely used on Douglas, Grumman, Boeing, and other aircraft.

Still another application of plastics tubing lies in flight testing. It is sometimes necessary to obtain actual measurements of static pressure, shock pressure, and so on, over many points of the wing surface. Large numbers of flexible lines become necessary, lashed together so that they will not vibrate and rub against metal. If these lines are transparent and filled with mercury, picture records of the fluid movements during test flights make possible an accurate check of flight instruments. Compar lines have met all these requirements.

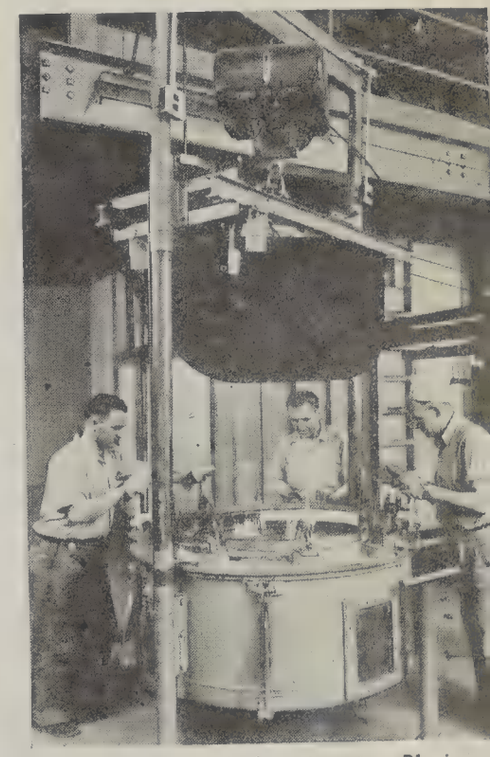
CHEMISTRY IN THE B-29—Other leading chemical companies are making significant contributions to aviation. For example, at a single plant, the Du Pont Chambers Works, 80 chemicals are produced that go into the Superfortress as ingredients or finished products. By



Sperry Gyropilots on vibrating test tables, connected with plastics tubes

electrolysis of a water solution of salt, chlorine and caustic soda are obtained. From these two neophrene is made. A synthetic rubber resistant to oils and to flame, neoprene is used for covering on electric wiring and for carburetor diaphragms on the B-29. Again, chlorine enters into the ethyl-chloride used in making tetraethyl lead, the anti-knock compound essential for high octane gasoline. Rubber has to be well-compounded before it goes into the molds, and to improve the rubber compounds' resistance to aging, "Zenite" made from coal-tar chemicals is employed. A few drops of anti-oxidant made from petroleum chemicals prevents gum formation in gasoline.

Such examples could be multiplied indefinitely. Thus, huge tires of Army bombers or cargo planes can withstand the heavy punishment involved only because the tires are made of nylon cord. In "air pick-up" work, All-



In making an airplane turret, a Plexiglas sheet is clamped to a vacuum pot and drawn downward before the cloth-covered, turret-shaped form, shown above the pot, is released

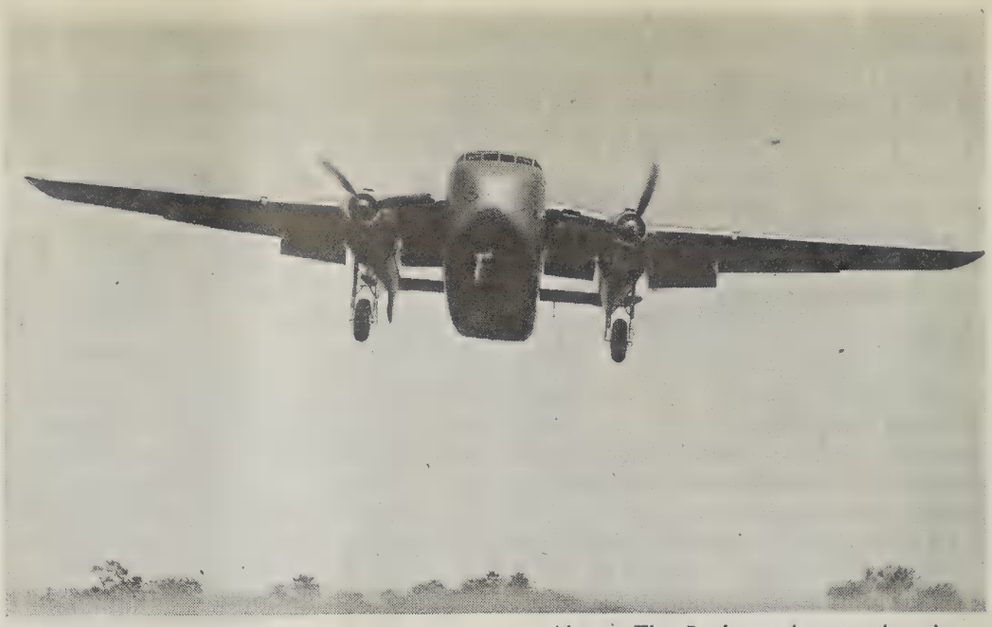
American Aviation in its first year of operation used manila rope and steel cable. The combination worked well but involved the use of a mechanical shock absorber. Now the work of the chemist has replaced the steel cable by nylon rope which stands abrasion better, and also avoids the use of a mechanical shock absorber. The shock-absorbing property of nylon is explained by hysteresis, or internal friction. When a rubber band is stretched and let go, the energy is released in the form of a quick snap. But the energy stored up in a nylon rope when the airplane's grappling hook catches the mail pouch at 110 miles an hour, is released largely as heat, owing to this internal friction. Only a part of it is converted to recoil, which accounts for the smooth performance of nylon rope in air-mail pick up.

While for structural airplane parts thermosetting plastics are used, the transparent parts employ thermoplastics, with acrylics as a foundation, for the Plexiglas used in bomber noses, gun blisters, and other airplane enclosures. In the latest version of the P-47 Thunderbolt, the "bubble" canopy of one-piece construction not only gives the pilot unobstructed vision in all directions, but it also eliminates metal framework, saves weight, and reduces head resistance.

It is not too much to say that chemistry, by bringing forth the synthetic adhesives, has revolutionized the whole art of aircraft wood and plywood construction, since it has removed bacterial decay, provided water-proof glues, and suggested new and remarkable processes of fabrication. An example of this is the Redux process of bonding metal to metal, and metal to wood. Redux is a new type of thermosetting synthetic resin adhesive. By its aid, joints are produced without riveting or welding. This process opens up many possibilities in composite construction. The bonding process involves cleaning of surfaces, application of Redux liquid and powder, and joining the metal surfaces under substantial pressure at approximately 240 degrees, Fahrenheit.



Sheets of impregnated glass cloth are used to line fuel-cell cavities



Above: The Packet takes to the air
Below: An armored car rolls aboard



To the chemist there is also credited a new inorganic compound which prevents the dangerous thickening of aviation oils at sub-zero temperatures or their excessive thinning in tropical heat. The importance of this will be realized when it is remembered that oils are used in lubrication, in brake actuation, in lowering and raising landing gears, and in operating turrets, control surfaces, and variable pitch propellers.

All these contributions of chemistry to aviation and many more for which there is not space in this article are cogent testimony that the chemist is indispensible to the expanding science and industry of flight. They show with equal weight that aeronautics offers the chemist a wide field for further research.

CARGO PLANE

Can Readily be Converted To Passenger Use

The War Department has finally permitted information to be released on the Fairchild military cargo plane already successfully test-flown by the AAF and now in production. The new ship is officially designated as the Fairchild C-82 and has a number of distinctive features which will give it a peace-time future as well as immediate military importance.

The fuselage is almost square in cross-section, with the interior wholly unobstructed. Because the tail surfaces are carried at the ends of two booms running from the wing, the rear of the fuselage can be opened up completely, giving space enough for a tank to roll up the ramp under its own power. Vertical walls and unobstructed cargo space for the entire length are provided. Use of a tricycle landing gear makes the floor of the cargo compartment parallel to the ground. The fuselage platform is the same height as that of a standard truck floor, for easy transfer of freight from a truck to the airplane.

The machine is primarily designed for carrying tanks, ammunition, supplies, troops, or paratroops to combat areas, but it is estimated that the "Packet," as the C-82 is also called, can carry as many as 76 passengers by day and 30 by night in upper and lower berths on both sides of the aisle.

The construction of wing and fuselage is of the most modern monocoque and high-strength aluminum alloy type. The lower portion of the fuselage is provided with seven longitudinal beams which take the floor and tie-down loads in the main cargo area, beneath the plywood covered floor.

ASSISTED TAKE-OFF

Would Make Use of Driven Landing Wheels

In the London *Aeroplane*, S. W. G. Foster suggests a new method of providing assisted take-off.

The idea is to drive the wheels directly from the engine at a time when the airscrew itself is somewhat inefficient. There is little doubt that take-off would be shortened, but would the additional complexity of mechanism be worthwhile?

Metals Fight Corrosion

Improvement of Alloys and Coatings to Combat the Ravages of Corrosion is One of Today's Most Hopeful Industrial Trends, Involving Both Metals and Chemicals. Industrial and Consumer Products Last Longer, Look Better, and Make Everyone Concerned Happier

MANY of the applications of metals and alloys in industry and everyday life are fronts in that perpetual battle between metals and chemicals that man calls corrosion. For centuries the combat has been an expensive one for metals and for society at large. It was once reliably estimated that losses traceable simply to the corrosion of metal products are in excess of two billion dollars each year. Yet so much progress has been made in recent years in retarding this evil that we may look with reasonable assurance for a continuing decline in the proportionate economic loss represented by metal-corrosion.

Certainly the checking of corrosion is recognized as one of today's most important engineering and scientific fields. Hundreds of first line metallurgists, chemists, electro-chemists, and engineers are continually investigating it from either the fundamental or practical point of view.

The leading technical societies have formed the Coördinating Committee on Corrosion, while every important metal producer and many large metal consumers like the Bell system, General Electric, Westinghouse, the War Department, the Navy Department, General Motors, Crane, Babcock and Wilcox, and so on, maintain a staff of corrosion specialists to find out why and to what extent metals are corroded by specific environments, or to develop alloys, coatings, or inhibitors to resist or eliminate the corrosion.

Corrosion problems may be divided into four broad types. The most prevalent manifestation (and the most costly to society) is corrosion of metals by the ordinary atmosphere. The chief example of this is the familiar rusting of iron. The second major corrosion field is marine corrosion—the attack on ship parts and cargoes by sea water or the salt sea air—and may be considered a special case of the first.

The third is the corrosion of machinery parts, industrial equipment, and other products by corrosives other than air or salt water. Outstanding representatives of this are the attack of lubricating oil on engine bearings; the embrittlement of steam boilers by the combined effects of alkali in the water and heat; the damage done to cooking utensils by certain foods; the destruction of pickling and plating equipment and parts by the solutions used; and so on.

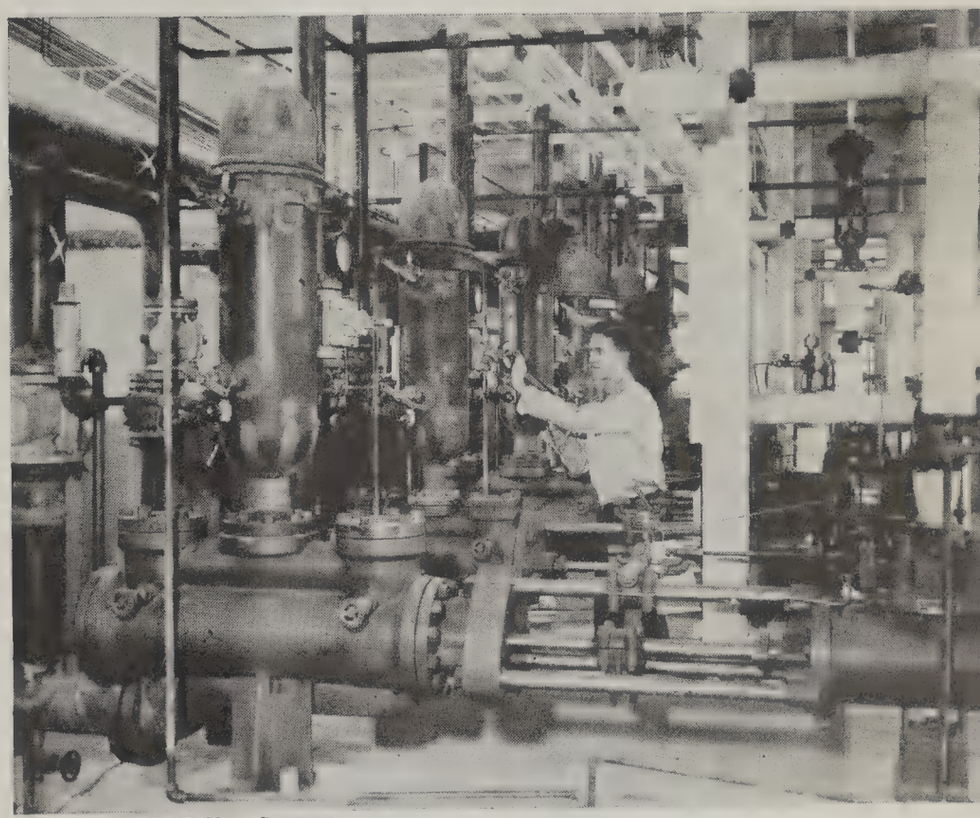
The fourth, again, is a special case of the third, but is perhaps the most important technical phase of corrosion: the corrosion of equipment used in the chemical manufacturing and process industries. Much of the broad general advance in battling corrosion has stemmed directly or indirectly from work originally done specifically to solve a corrosion problem involving equipment used in the chemical process industry.

WHAT CORROSION IS—The questions of how and why metals corrode—the so-called "mechanism" of corrosion—have produced several answers down through the years. The theory enjoying widest acceptance at the present time is called the electrochemical theory. According to it, each case of corrosion involves a flow of electric current, something like the flow of current in a battery and the accompanying corrosion of the plates, on a miniature scale.

Virtually every metallic surface or structure contains non-homogeneities. Each of these behaves like a little electrode, while the metal itself acts as another electrode in contact with it but differently charged. Finally there must be a driving force or "potential" to start the flow of ions from the metal into the attacking solution.

This potential is different and characteristic for each metal and a listing of metals in accordance with the potential of each—that is, its relative tendency to dissolve in solutions of its salts—gives rise to the so-called "electromotive force series," of which a condensed form is shown in the left-hand column of the accompanying table. The right-hand column is a somewhat "practicalized" version, showing the position of several familiar alloys as well as the more common pure metals.

This table may be used for a variety of practical corrosion problems. It



Courtesy U. S. Rubber Company

The equipment in this pumphouse for synthetic rubber chemicals illustrates the need in industry for metals that are strong as well as highly resistant to corrosion

shows, for example, the general tendency of the individual materials to be corroded by the atmosphere, those near the top being more rapidly attacked than those near the bottom. Aluminum, for example, is near the top and is avidly attacked by ordinary air, while Monel metal, near the bottom, is affected but slowly. That aluminum kitchen equipment remains just as bright and uncorroded as Monel is caused by the fact that the quickly-formed oxide on aluminum is highly impervious and is so thin a layer as to be invisible, but nevertheless adequately and immediately protects the underlying metal against further attack.

The table also shows *very roughly* the relative corrosion resistance of the metals to chemicals in general. However, it could never be used with safety for predicting their relative resistance to a specific corroding solution, say sulfuric acid or sodium hydroxide or salt water. Only tests—usually full-size service performance tests—will show that accurately.

"GALVANIC" CORROSION—An important practical use of the table by corrosion engineers is to determine whether "galvanic" corrosion is likely to occur in a given design and how to avoid it. Galvanic corrosion is the corrosion of one metal in contact with a second in an environment which the first metal alone (that is, not in contact with the second metal) would normally resist. For example, an aluminum shaft for the mixing paddle in a tomato juice vat might operate without noticeable corrosion if the paddle blades also were aluminum. If the blades were made of bronze, however, the aluminum shaft might be seriously corroded.

Each of the metals listed in the right-hand column of the table will tend to accelerate the corrosion of any metal *above* it when the two are placed in contact in a corroding solution, while the lower-placed metal will be relatively unaffected—actually protected sacrificially. Metals grouped together in the table have no important galvanic effect on each other and may be coupled or allowed to come in contact in a product-assembly without trouble, but other in-contact combinations (except where one metal completely seals the other from exposure to the environment) are studiously avoided by the careful corrosion engineer.

This and other knowledge about metals has been applied to improving the resistance of materials to corrosion in three broad ways: (a) developing and utilizing new alloys possessing special resistance to atmospheric or chemical attack; (b) formulating and applying protective coatings, either metallic or non-metallic, to shield the vulnerable metal from destruction; and (c) controlling the service conditions—either the design of the corrodible equipment or the character of the corroding medium—of individual situations.

For example, in the first of the broad corrosion-problem fields—atmospheric corrosion—the basic problem of the rusting of iron and steel has traditionally been solved with varying degrees of success by painting, vitreous enameling, galvanizing, tinning, chromium-plating, and so on, all representative of protection by the application of coatings. The iron is also alloyed with chromium or nickel or both to produce alloy steels with considerably better rust resistance than ordinary steels, and to produce stainless steels which, although not really "stainless", are virtually "rustless" or non-rusting under usual conditions.

Painting, the most-used method of protecting metals against atmospheric corrosion, has been radically improved in effectiveness in recent years. Better primers and especially "inhibiting" primers that protect the metal chemically as well as physically have been developed.

New resin lacquers provide protection and flexibility once difficult of attainment simultaneously. Used on tinplate closures and food containers during the war, these finishes have demonstrated post-war possibilities in fabricating metal parts from pre-coated sheet metal. The successful use of baked resin coatings on the inside of steel pipes and tubing for heat exchangers and low-pressure boilers has also opened up new fields to these highly corrosion-resistant coatings.

Metallic coatings, too, are entering what promises to be a new era of usefulness. Lead alloy coatings developed during the war are harder, more fatigue- and creep-resistant, and more corrosion-resistant than earlier lead coatings. The electrolytic tin plating process, developed to save critical tin, has shown that thinner tin coatings of adequate protectiveness can be advantageously used for many products, especially when treated with a new filming agent that inhibits the rusting of the tinned material.

Zinc coatings have made remarkable progress—new chemical treatments for zinc-coated steel have improved the utility of that material, while the expansion in use of continuous electrolytic lines for depositing high-purity zinc at high speeds on steel sheet offers many possibilities for pre-plated metals in the post-war period, with some interest being shown in the possible use of zinc coated steel for automobile body stock.

COATED STEEL—A recently developed flat-rolled corrosion-resistant product of considerable interest for the future is hot-dipped aluminum-coated sheet and strip steel, which combines the corrosion-resistant characteristics and surface-appearance of aluminum with the strength of steel. New virtreous-enameling steels and enamels have also been introduced that permit the production of white or colored one-coat (no ground coat necessary) finishes direct to the base metal that are equal in protectiveness and appearance to former multi-coat wares and which last longer because of the reduced chipping of the thinner coat.

Sea-water corrosion problems, especially prominent in wartime, have stimulated metal-protection developments of far-reaching importance. The most spectacular have been in the rust-proofing and packaging of steel war products to assure their arrival at the point of combat use free from rust and other damage. Rustproofing treatments ranging from improved slushing oils all the way to highly engineered chemically applied rust-inhibiting black coatings have been successfully developed for tiny parts.

One outstanding new development in this field is the plastics-dip-coating, applied by dipping the cleaned part in a hot ethyl-cellulose mixture and removing. The film dries immediately to give a continous, tight-fitting, perfect-seal wrapping for the part. For larger parts, loose-fitting film bags, containing a desiccant like silica gel, are widely used.

Sea-water corrosion has always been one of our toughest engineering problems. Copper alloys as a class have given the best service, with such materials as manganese-bronze, aluminum-bronze, the silicon-bronzes, admiralty metal, the cupro-nickels, and aluminum-brass outstanding performers in this group. Nickel and its alloys have also been highly useful in sea-water or sea-air applications. A seldom-appreciated

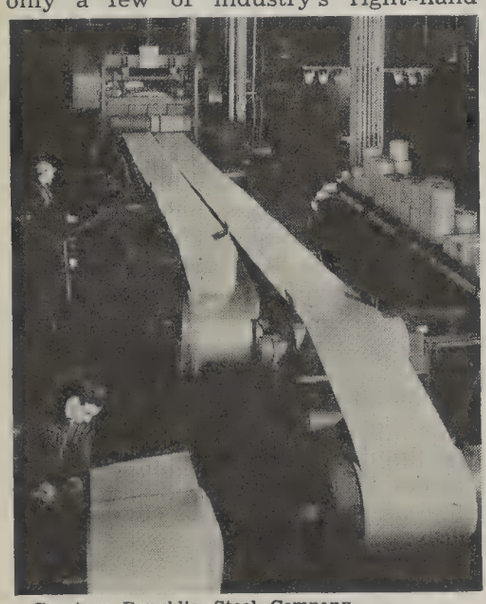
The Electromotive Force Series of Metals

Theoretical Listing	Practicalized Version
Anodic or Corroding End	
Lithium	Magnesium
Rubidium	Magnesium Alloys
Potassium	Zinc
Strontium	Pure Aluminum (2S)
Barium	Cadmium
Calcium	Aluminum Alloy (17ST)
Sodium	Steel or Iron
Magnesium	Cast Iron
Aluminum	Chromium-Iron (active)
Beryllium	Stainless Steel, 18-8 (active)
Uranium	Lead-Tin Solders
Manganese	Lead
Zinc	Tin
Chromium	Nickel (active)
Gallium	Nickel-Chromium Alloy (active)
Iron (ferrous)	Brasses
Cadmium	Copper
Indium	Bronzes
Thallium	Copper-Nickel Alloys
Cobalt	Monel Metal
Nickel	Silver Brazing Alloys
Tin	Nickel (passive)
Lead	Nickel-Chromium Alloy (passive)
Iron (ferric)	Chromium-Iron (passive)
Antimony	Stainless steel, 18-8 (passive)
Bismuth	Silver
Arsenic	Graphite
Copper (cupric)	Gold
Polonium (18° C.)	Platinum
Copper (cuprous)	
Tellurium	
Silver	
Mercury	
Lead	
Palladium	
Platinum	
Cathodic or Noble End	

but highly important property of modern gray cast irons is their superlative resistance to sea-water corrosion, a characteristic that has led to their application for marine propellers and similar jobs.

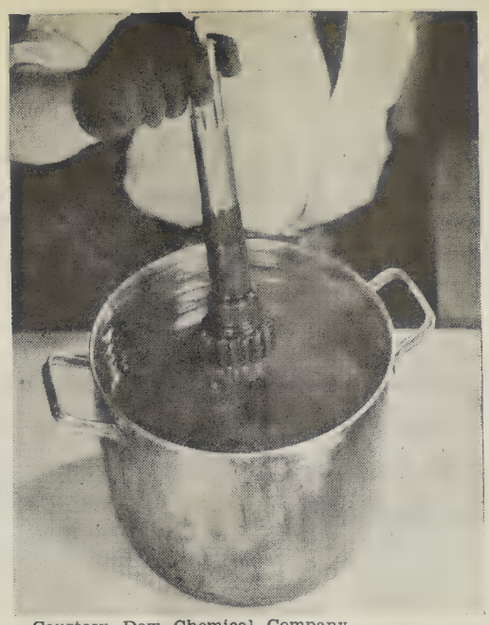
ALLOYING AGAINST CORROSION—It is in the industrial-corrosion field, of course, that the greatest diversification of problems and materials exists. Here the problems are more likely to be solved by alloying rather than by surface coating, for first cost is usually less important in industrial equipment than it is in finished consumer products. There has, however, been a trend to the use of clad metals (especially steel clad with stainless steel or nickel or nickel alloys or copper alloys), which combine a highly corrosion resistant but expensive thin surface layer with a cheap underlying material.

Among the newer alloys or applications of outstanding interest in the solution of industrial equipment corrosion problems are the cobalt-chromium-tungsten and the nickel-base molybdenum alloys. While these are more expensive and not as workable as less corrosion-resistant materials, they have found increasing use, nevertheless, because of their resistance to most chemicals and to high-temperature oxidation. Other innovations include bearings made by heavily plating silver on a steel back, then plating lead and indium over the silver, and finally diffusing the indium into the lead. Treated in this fashion the bearings have excellent resistance to lubricant corrosion and good bearing qualities in general. Another development is that of new aluminum alloys containing zinc and magnesium whose generic tendency toward stress-corrosion cracking has been reduced to such an extent as to permit full utilization of their excellent mechanical properties. Specially-treated (stabilized) stainless steels containing titanium or columbium are also widely used in the struggle against corrosion. These are only a few of industry's right-hand men wherever resistance to corrosion, scaling, or mechanical failure, alone or together, are involved.



Courtesy Republic Steel Company

Straight-line pickling and normalizing equipment for wide stainless steel strip was constructed to meet the expanding demand for this metal



Courtesy Dow Chemical Company

When dry, the hot plastics in which this metal part has just been dipped will leave a tight-fitting corrosion-proof, and protective wrapping

In the construction of their equipment, the chemical process industries have done remarkable things with aluminum alloys, copper alloys, and the noble metals like silver and platinum. Tantalum has found new prominence in the process-industry equipment field because of its unusual resistance to acid attack. Stainless steels containing molybdenum do yeoman duty in petroleum processing equipment. Glass lined vessels and piping become ever more numerous as their almost universal corrosion resistance is increasingly recognized. The clad steels previously mentioned are becoming standard equipment for heavy chemical equipment, the linings being applied either to fabricated vessels by spot welding, plug welding, or strip lining, or in multi-layer construction.

Attention to the service factors surrounding individual corrosion problems has also been successful. Designers of salt-water condensers limit the water velocities to suit the materials used. Knowledge of galvanic corrosion fundamentals leads to the use of valve trim materials (like Monel) more noble than valve bodies (bronze) so that the vital working parts will be protected without serious harm to the bodies. Cathodic protection, too, is being utilized on a more scientific basis than ever before.

The story of corrosion and how it its being licked is an outstanding example of scientific co-operation, for the pooled knowledge and effort of the chemical engineer and the metallurgical engineer have brought us farther in the last 20 years of our battle against this worst ravager of man's handiwork than we had gone in all previous centuries of history.

MAGNESIUM ALLOYS

Have Greater Toughness, Higher Yield Strengths

RECENTLY announced by Dow Chemical Company is a new sheet magnesium alloy, having 5 percent aluminum and 1 percent zinc, designated as Dowmetal 251X. This alloy retains the strength and weldability of the previous 6.5 percent aluminum, 1 percent zinc alloy, and has greater ductility and toughness.

Another interesting development is a heat treating practice for extruded magnesium alloys of the 8 percent aluminum, 0.5 percent zinc type which gives higher yield strengths, especially in compression, than have been previously available. Originally developed as an experimental alloy for all magnesium aircraft primary structures, this material is now commercially available with minimum yield strengths of 30,000 pounds per square inch in both tension and compression.

THREAD GAGES

Made of Cast Iron to Provide Notable Savings

ONE of the war's worst production bottlenecks has been the supply of steel gages for dimensional inspection. Some manufacturers have solved the problem by using specially processed high-strength cast iron for thread gages, with notable savings in production time, operating costs, labor, and critical material.

In the conventional plug thread gage the handle and gaging member are manufactured separately. The cast iron (actually Meehanite iron) gage is a one-piece unit, with the handle and gage cast integral. Engineers who have adopted the practice of making these gages of cast iron report considerable savings in cost because of cast iron's better machining properties and lower material cost than those of tool steel and because the cast gages have about 25 percent longer life in this application.

NICKEL ALLOYS

Represent Advance in Heat-Treatable Metals

A SIGNIFICANT materials-engineering development of recent years has been the growing interest in and use of heat-treatable nonferrous alloys such as beryllium-copper and "Z-nickel" for springs and similar applications. Information on the composition and general age-hardening behavior of the nickel-base alloys has just been released by W. J. Kroll.

Nickel is made hardenable by simultaneous additions of magnesium and carbon, a maximum hardness of 405 Brinell being reported for an alloy of 0.6 percent magnesium and 0.4 percent carbon. Higher hardnesses are available in heat-treated nickel-beryllium alloys, but the costs are not so favorable.

Chemicals On Rails

Expansion of Many Chemical Industries Has Been Made Possible Only by Co-Operative Measures Taken to Reduce the Hazards of Bulk Shipments of Explosive, Flammable, and Other Dangerous Materials. Intensive Research Has Resulted in Safe Methods of Shipping by Rail

AFTER World War I the chemical industries entered a period of rapid expansion, both as to volume and variety of products. The multiplication of plastics materials during recent years has captured the popular imagination. In this expansion railway transportation has played a special part which has brought it into particularly close relationship with many chemical industries. This special relationship has two aspects—the work of the Bureau of Explosives and the development of special types of tank cars which have stepped up the transportation of many chemicals from carboy lots of a few gallons each to carload lots of thousands of gallons each.

The first steps in this transportation progress were taken when a movement was begun through the American Railway Association for the development of a uniform code of rules to be observed by all member roads. Such a code was formulated and adopted and the job of enforcing it was entrusted to a Bureau for the Safe Transportation of Explosives and Other Dangerous Articles created under the auspices of the Association.

The function of this organization, commonly called the Bureau of Explosives, has been far more than that of a policeman enforcing a code of rules. The Bureau has become expert on all conditions affecting safe transportation of all dangerous articles. One of its earliest activities was a series of impact tests to measure the forces of coupling and train-operating shocks and to relate these to the strength required in containers for the transportation of all kinds of dangerous articles.

In carrying out this function it has tested many types of containers to destruction and has developed complete specifications for a variety of steel cylinders; steel barrels with and without linings of lead, aluminum, or rubber; wooden barrels and kegs; metal kegs; fiberboard boxes; wooden boxes, nailed and wirebound; glued plywood boxes; wooden, plywood, and fiberboard drums; rubber, steel, and aluminum drums; mailing tubes; carboys; paper and cloth bags.

The Bureau early won the confidence of the manufacturers of dangerous articles. The industries have co-operated with the bureau in its investigations, in its own chemical laboratory, of the characteristics of many materials. These investigations have brought to light instances where improvement in uniformity of certain characteristics as well as changes in quality have brought hazards under control.



An all-aluminum welded tank car designed for transporting peroxide

SAFE BULK SHIPMENTS—The first concerted effort to bring the hazards of transporting dangerous articles in tank cars under control was made in 1903 when the Master Car Builders' Association recommended simple specifications for improved construction of the tank and of the car as a vehicle. These were approved by the American Railway Association. They included the design of safety valves for use on cars loaded with petroleum products, ammonia, gas liquor, and turpentine. These were constructed so that one or two valves, depending upon the capacity of the tank, provided sufficient venting capacity to prevent a dangerous rise of pressure should the tanks be subjected to the direct heat of flames in fires connected with train wrecks.

Since that time, experience—including a number of disasters resulting from mishandling of highly volatile flammable products—also investigation and much testing, have led to modifications and additions to the first simple specifications so that highly volatile flammable liquids and compressed gases, both flammable and corrosive, are being handled in large quantities with a high safety record, proving the value of the work.

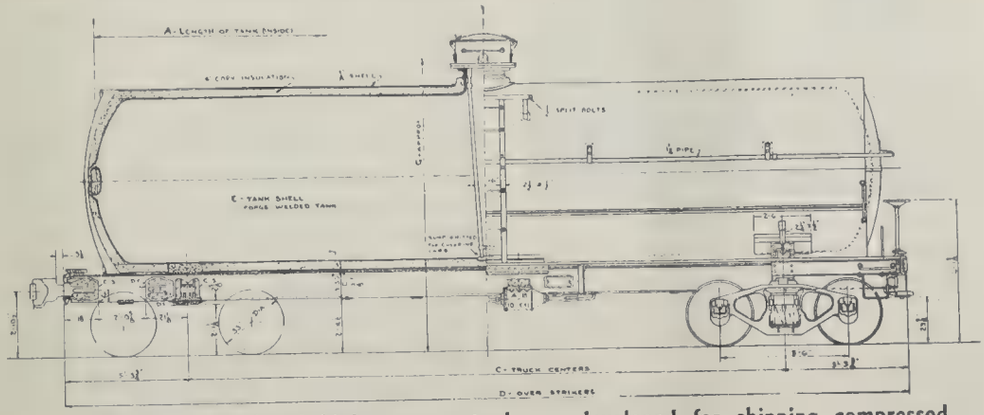
TAILOR-MADE TANK CARS—Since the beginning of organized effort to develop the tank car, the list of materials moving in these specialized cars has expanded tremendously. While many of these materials have been articles of commerce for a long time, their utility was greatly limited by the inability to transport them in containers of more than a few gallons each.

The development of high-pressure cars is one factor in this widespread release of chemicals from the limitations of the carboy. Another important factor has been the development of tanks of special materials, and steel tanks with linings of materials suitable to protect these chemicals from contamination and to resist the destructive action of corrosive materials. A few illustrations will make clear how the development of suitable tank cars has changed the commercial character of many materials by making bulk shipments possible.

Until 1914 the production of chlorine was a very limited enterprise and the gas was transported in small cylinders. When high-pressure tank cars became available, 16 tons of chlorine could be shipped in a single container. Hun-

dreds of these cars are employed in this service. Some of the newer ones move 55 tons of chlorine in a single load. This powerful oxidizer is used in large quantities as a bleaching agent, particularly in the textile and paper industries.

Anhydrous ammonia is another compressed gas formerly limited to transportation in cylinders. It now moves in high-pressure tank cars, 25 tons to the container. Its price per pound in tank-car lots is about one sixth of its former price in cylinder lots. It was formerly used for little else than a refrigerant; at its present price it has become a practicable constituent of fertilizers.



Drawing of an insulated high-pressure tank car developed for shipping compressed gases such as chlorine, sulfur dioxide, anhydrous ammonia, and propane. Some cars of this type are strong enough to withstand gas pressures up to 450 pounds per square inch

The helium tank car is an extreme example of what can be done in the transportation of compressed gases. The considerations which led to the development of this car were set forth in a paper by R. C. Pierce, vice president, General American Tank Car Corporation, presented before the American Society of Mechanical Engineers, from which the following is extracted: "Large quantities of high-pressure gases naturally present problems of safety. . . Several years' study of this problem resulted in the construction of a multi-tank type of helium cars. A long, small-diameter tank with a comparatively thin wall. . . made heat-treatment easier. . . The greatest design problem was in the anchorage of the tanks. The tank stresses, due to their weight and the internal pressure of the gas, could be readily calculated. It would be quite impossible to calculate the stresses which the tanks might receive if they were subjected to forces caused by the twisting of the car structure. . ."

The imposition on the tanks of stresses caused by the motion of the car structure was prevented, he said, "by supporting each end of each tank in a bulkhead, alternate layers being anchored at each end of the car. The anchoring of each tank against longitudinal motion was accomplished at one end, the opposite end of the tank being permitted to slide back and forth with reasonable freedom in the opposite bulkhead."

Each tank is tested at 2750 pounds per square inch. The empty weight of the car is a little more than 100 tons. Despite the fact that the payload is only one ton, these cars are said to have paid for themselves in about 14 round trips.

When synthetic glacial acetic acid reached production on a commercial stage, the rapid growth of the rayon industry called for increasing amounts of this material. Tests indicated that it could be transported in tanks made of certain aluminum alloys,. (As a matter of fact, the first aluminum tank car was built expressly for this type of transportation.) In developing this car considerable experimentation was necessary before there was reasonable assurance that it would meet the requirements of railway operating conditions. A number of aluminum cars have since been built for this service.

Everyone is familiar with hydrogen peroxide as a household antiseptic and bleach. In its drug-store form it is a very dilute solution. In concentrated form, however, it is a dangerously active oxidizing agent. Its transportation was formerly limited to carboys of 13 gallons each. In 1931 a 4000-gallon aluminum tank car was built to meet the demand for the movement of hydrogen peroxide in large quantities to be used as a bleaching agent in the textile industry.

In building this car special care had to be exercised in the choice of material. The aluminum alloys had to be low in manganese, iron, and titanium. But such an alloy was of low strength. To develop adequate strength it was necessary to fabricate the tank parts and then heat-treat them before assembly. The tank rivets had to be heated in temperature-controlled electric furnaces and driven quickly within a prescribed temperature range.

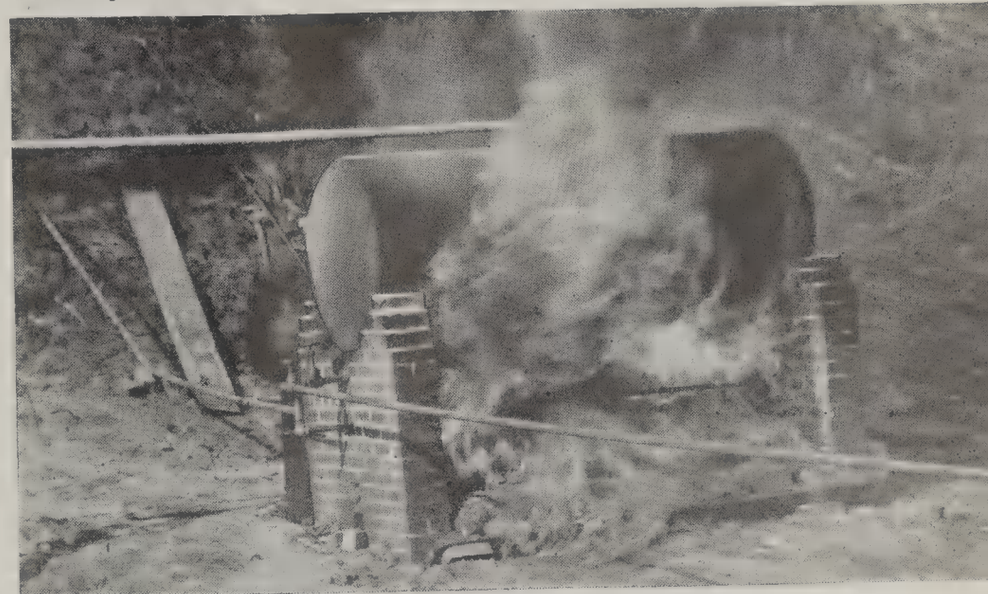
Aluminum cars constructed for transporting peroxide illustrate how a need in one branch of industry influences developments in other industries. To satisfy the desire of a chemical industry to expand the market for its product, a satisfactory aluminum alloy had to be found and the tank-car builder had to develop a special technique of construction.

NICKEL-CLAD STEEL—Another instance of this kind of inter-industry co-operative effort was the solution of the problem of producing nickel-clad steel plates so that steel tank cars could be built with integral nickel linings. The pressure in this case came from a desire to transport phenol and caustic soda in large quantities protected from contamination. The movement of phenol and a growing list of other chemicals in large quantities, free from iron contamination, was one essential in the growth of the plastics industries.

The production of nickel-clad steel involved a problem of rolling-mill technique, in the solution of which the car builder and the metal producer co-operated. In the end it was solved and in the finished sheet the nickel, varying from 10 to 20 percent of the combined thickness of the two metals, is completely welded to the steel.

Highly concentrated sulfuric acid for most commercial purposes can be shipped in steel tank cars. In this state its action on the metal is too slow to constitute a serious corrosion problem and the iron contamination is not detrimental to the commercial use of the acid. In a less concentrated form, sulfuric acid is used in storage batteries. Acids shipped for this purpose must be protected from iron contamination, and this requires a lead-lined tank.

OTHER LININGS—For the protection of the car and the prevention of contamination by muriatic and phosphoric acids, rubber linings are applied to the interiors of steel tanks. This lining



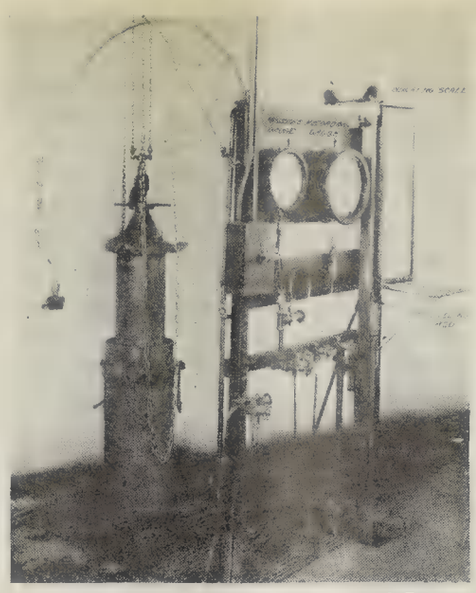
Simulating a wreck fire and its effect on a miniature car tank. From such tests comes valuable information on safe methods of transporting dangerous compressed gases

is also used for the shipment of formaldehyde. Cars with inner tanks of stainless steel are hauling nitric acid, acetic acid, acetic anhydride, butyl acetate, butyl aldehyde, formaldehyde, acetaldehyde, and butyric acid.

A number of baked-on varnish linings are in use for the transportation of caustic soda. They are short lived, however, and not altogether reliable, and nickel-clad tanks are being used in this service.

Neither the sprayed-on metal linings of tin, zinc, or aluminum, nor glass linings are important factors in the chemical industry. Because of their porous nature the sprayed metal linings do not completely seal off the steel from the contents, but do so sufficiently to protect wines and syrups. Glass-lined cars are more generally used for milk and beverages than for chemical products.

A good indication of the close relation of the chemical industries to the agencies that develop and operate tank cars is the fact that the Manufacturing Chemists' Association has a tank-car committee of its own. Thus there are, working together in the solution of the special problems involved in giving new chemicals an opportunity to serve the American people on a vast scale, the Government, represented by the Interstate Commerce Commission; the railroads, represented by the Tank Car Committee of the Mechanical Division, Association of American Railroads, and the Bureau of Explosives; the builders of tank cars; and the producers of materials which are inert to the various active chemical agents now regular articles of commerce.



Apparatus used by the Bureau of Explosives for testing compressed gas cylinders. A water jacket is used to permit accurate measurement of volumetric expansion under pressure

FREIGHT CARS

Superstructures Built of High-Strength Alloy

First orders for aluminum box cars, now being turned out from the plant of the Mt. Vernon Car Manufacturing Company, consist of ten cars each for the Alton, the Rock Island, and the Minneapolis & St. Louis. The superstructure material is the same high-strength aluminum alloy employed in the B-29 Superfortresses. It was furnished by Reynolds Metal Company who also designed the cars.

The entire car-body structure, including the frame members, the side sheathing, corrugated ends, and roof, are fabricated of the aluminum material. The center sills and other underframe parts, however, are all-steel and the underframe is built like that of a standard steel box car. Five of the Rock Island cars are fitted with Timkin roller bearings. The car body has standard inside dimensions.

The cars weight about 4½ tons less than would a standard all-steel car of the same dimensions.



Aluminum alloy in this freight car body structure saves 4½ tons

DIESEL LOCOMOTIVES

Pile Up High Mileages Between Overhauls

Between August, 1940, and September, 1944, Diesel-electric locomotive Number 9-M-1A of the Union Pacific Railroad, one of six assigned to its Kansas-City-Denver run, completed more than 1,049,000 miles without a major overhaul. At present it is not intended to shop this locomotive until some time in 1945. Diesel locomotives on the "City of Denver" of the Union Pacific Railroad and the Chicago & North Western Railway have traveled more than 3,000,000 miles each in eight years without shopping for general repairs.

Modern steam locomotives require shopping after 200,000 to 275,000 miles, at which time the machinery is torn down, repaired and reassembled, and the boiler tubes removed, cleaned, and reset.

MODERNIZATION

Reflects 30 Years of Locomotive Progress

Ten Pacific type passenger locomotives (a four-wheel leading truck, six driving wheels, and a two-wheel trailing truck) on the Alton were built 30 year ago to handle regular trains of seven cars on a schedule of eight hours for the 282-mile run between St. Louis and Chicago. Six years ago these locomotives were improved by adding five feet to the length of the tender and thus increasing its capacity.

The locomotives were also equipped with stokers and improved grates, thereby relieving them of the limitation of the human fireman and improving combustion. The boiler pressure was raised from 200 to 220 pounds per square inch. The regular train was then increased to 11 cars, and the schedule reduced from eight to 6½ hours.

In 1941, because a railroad was not then permitted to purchase new passenger power, the Alton decided to meet its urgent need for added power to handle heavier passenger trains by further improving the old Pacific type locomotives. This time feedwater heaters were added, the fireboxes were rebuilt to include Thermic syphons, new superheaters were installed, and an automatic device was provided to prevent boiler foaming. The feedwater heater increases the locomotive capacity and efficiency by reclaiming from 10 to 13 percent of the heat and saving nearly the same percentage of water, thus in effect increasing the tender capacity.

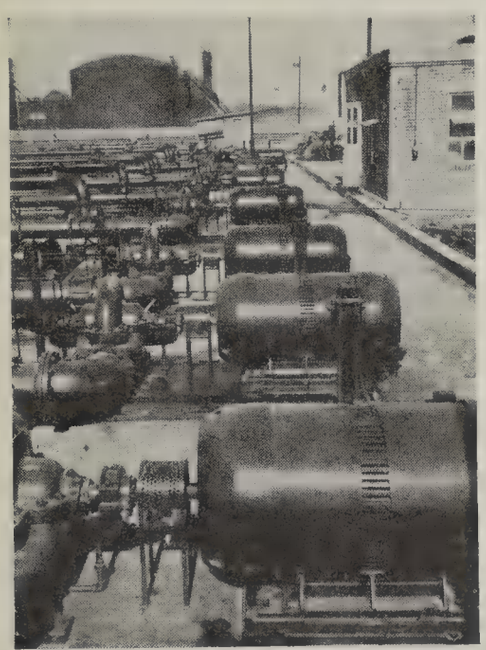
The modernized locomotives, although by no means as good as completely modern new locomotives, now handle 14 cars on a 5-hour, 50-minute schedule.

Minimum Maintenance Motors

With New Markets in Sight, Electric Motor Manufacturers are Bringing Out New Motors That are Proof Against Practically All Industrial Hazards. They Will Operate Under Formerly Impossible Conditions and Will Give Better Service With Less Servicing and Greater Profit

THE chemical age is bringing a brand new era to the electric motor. Motors are now being made so they can be put almost anywhere, without regard for explosive dusts, flammable fumes, lint, abrasives, and other ancient enemies. Oil can drip on them, water from a hose can be squirted full blast on them—they take all sorts of abuses which a few short years ago would have been positive causes of shutdowns. And even more important, every time a motor becomes master of one of its ancient enemies the maintenance cost of keeping that motor running is reduced accordingly, and the motor can be used with greater profit.

Such improvements can have only one result. More motors will be used in factories, homes, mines, on farms—everywhere. And there is room for more. The Electrical Manufacturers Public Information Service tells us that only 200 million electric motors are in daily service in the United States. This is less than one and a half motors for each member of the population. With better protected motors that give



There is no danger when these explosion-proof motors pump aviation gas

less trouble and need less care there will be plenty of use for ten times that number.

To any old-timer the present trend amounts to a revolution. He saw a few "explosion-proof" motors being developed some 25 years ago for use in mines—motors had to be safe the miner's safety lamp if they were to be used where explosive gases might accumulate. Most of these motors depended upon labyrinth seals at their ends to keep explosions of gases within the motors from getting out and igniting gases outside them. (Flame refuses to turn the many corners of a labyrinth.)

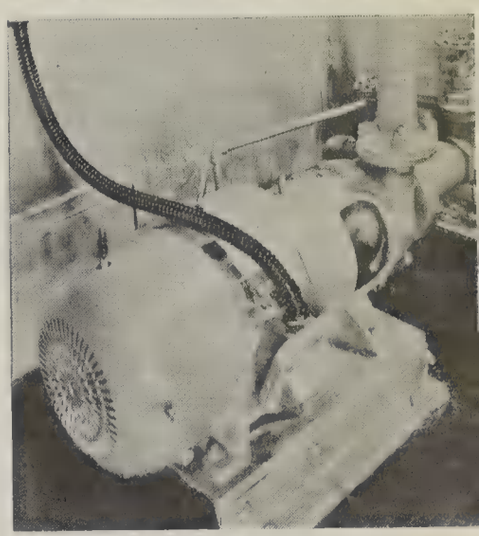
But most of these motors failed to be explosion-proof and few would meet modern safety rules. There also were small enclosed motors for automobile starters, vacuum cleaners, and the like, but these were not expected to deliver much power nor to run steadily for long periods. So the old time electrician treated his ordinary motors like fine watches, keeping them out of the way of dusts and oil fogs and even moisture fogs, cleaning them out carefully at regular intervals, and hoping for the best.

In the chemical industry such treatment of motors was nearly impossible. A few motors could be mounted far from any dangerous dusts and fumes and their power transmitted to the point of work by shafts, belts, chains, and the like. A few more could be put in especially air conditioned rooms close to the dangerous materials—a practice still in use for extra-hazardous places—but these also had to be linked by power-transmission sequences to the work points where the power was needed.

VERSATILE MOTORS—What the industry wanted was motors that could be put anywhere, left alone with very little attention, walled off where nobody could see them, turned on and off or changed in speed by automatic controls. Some of these motors would have to be specially constructed. No one yet has dreamed up a single type which will take every punishment or meet every hazard a chemical plant is likely to give it. Yet trouble-proof motors had to be built if the chemical industry was to develop.

Other industries were glad to get those motors too. The fume-proof motor was welcome at the oil refinery, the dust-explosion-proof one at the flour mill. Machine shops, wood-working plants, laundries, mines, every industrial user of motors wanted the new kinds. The trickle of specially protected types of motors coming on to the market grew into a deluge.

The most common improvement is to make the motor drip-proof or splash-proof. Most factories want to mount motors on the floors or to have them



Serving a pump, this fan-cooled motor is totally enclosed for safety's sake

underneath conveyors or the working levels of machines. There are many reasons for this. First of all, the floor nearly always is strong and rigid enough to hold the motor in place and in alinement while an overhead mounting may require special bracing.

The easiest connection between the motor and the device it is to drive may be at floor level or below the work level of the machine. In the old days of overhead driving shafts and long belts the driven pulley on the machine often was close to the floor level and this same spot is where it is easiest to attach the motor.

Another point is that overhead space is becoming more and more valuable. Controls are located there as well as materials handling equipment. Lighting comes mostly from the ceiling; the motor must not be in its way.

Drip- and splash-proof motors still depend largely upon air being sucked through them to keep them cool. They are so designed, however, that oil, wa-

ter, dust, or small objects falling upon them will not get into their internal parts.

One recent type has only its upper half enclosed, the bottom being open for ventilation. The ventilation is by fan which blows the incoming cool air up inside the casing to displace the warmed air which naturally rises inside the shell. Bearings, windings, magnetic core, and frame all are cooled by the fan.

Another has protected air inlets and exhausts with cross-flow ventilation. A protected top model has air drawn in from the bottom at both ends and exhausted from the sides. There is a fully enclosed job with rotor fan and conical baffles. While most splash- and drip-proof motors are of special dimensions, which seem to be made necessary by their protective shields, several models are being made to standard dimensions.

SPECIAL HAZARDS—Totally or partially enclosed motors protected against special hazards are being designed. One type is used in cotton mills or anywhere that lint is a problem. Lint has a way of gathering in hidden places, drying out, absorbing any oil which the air or any solid material brings to it (and oil will travel as fog or will seep to every part of a factory) and then catching fire. Textile mills have literally thousands of small unreported fires from this cause. But these motors do not hold lint; it simply falls or is blown clear.

Other types are specially designed for machine tools. It took years of slow development to work these out. As motor makers found out more and more about what to do, machine-tool makers put their motors closer and closer to where cutting oils might splash or steel chips and abrasive particles might fly. Now one machine that makes airplane engine cylinder heads has 80 electric motors and 15 miles of electric wiring to power and control its automatic motions—and this is not an unusually complicated machine tool.

Vertical motors (their shafts are vertical instead of horizontal) have been made drip- and splash-proof. In these the top ends may be totally closed. The old difficulty that lubricant put in the upper bearing would run down into the electrical parts, while it was almost impossible to oil the bottom bearing at all, has been solved by cartridge-type ball bearings in which the lubricant is sealed for the life of the bearing so that the motors never will need oiling or greasing. With such bearings, totally enclosed motors can be made to run in any position —horizontal, vertical, or at any angle.

Drip and splash problems are common enough, but explosion hazards are increasing too. Highly accurate machining, for example, is likely to produce metal dusts or chips so fine that they can act like dusts. And nearly any metallic dusts are explosive if mixed with air and ignited. Magnesium, bronze, and aluminum dusts are especially explosive, and the use of those metals is increasing.

Explosive and flammable gases exist not only in mines and chemical plants and oil refineries, but to ever increasing extents in factories of all kinds. Solvent fumes from the thousands of cleaning, lacquering, and stripping operations which are becoming so common, can accumulate rapidly in spaces near where the solvents are being used. Many a motor has to work right in the fumes. Natural and manufactured gases can leak; oils at any process can suffer fractional distillation and give off flammable fumes.

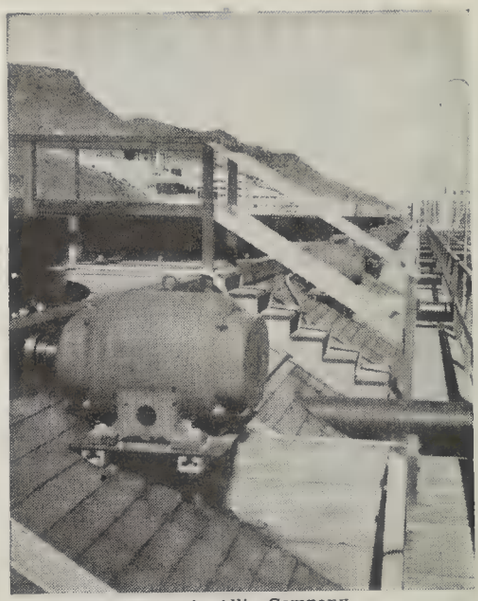
Present also are those organic dusts which have been blowing in grist mills, breweries, and coal screening rooms for generations. But for every one of these hazards the motor manufacturers either have the answer or are busily working it out.

STANDARDS—Their first step was to work with the National Board of Fire Underwriters, the American Standards Association, and others, to get a National Electric Code which covers all electrical practices for hazardous locations. This was done in 1940 and it has been amended since, but it poses some tough problems which have not been licked yet; or at least no solutions of them have been made public.

Acetylene gas is one unbeaten hazard. It stands all alone in Group A of Class 1 in the tables. Some of the other ones, especially those found in powder mills, are still on the recalcitrant list.

The code divides hazards into four classifications in accordance with how hard it is to keep the material of the motors, then lets the motor makers design their machines accordingly.

Gases constitute Class 1. The code assumes that they cannot be kept out of the motors and the motor control equipment; therefore all such equipment must stand up against internal explosions. This means that parts must be heavy. It helps to make the motor with inside clearances so small that very little gas can get in to explode at any one time.



Courtesy The Louis Allis Company

Weather-proof and splash-proof, these motors can do their job out-of-doors

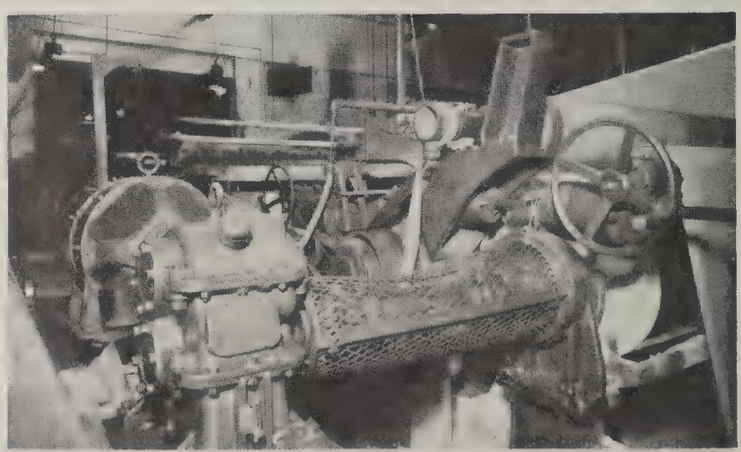
Class 2 includes dusts. Dusts can be kept out of electrical equipment but might go off with more force than dynamite if there was electrical arcing outside of the machine. Class 3 covers lints; easier than dusts to keep out of the motors but hazardous because they fly about in the air and are likely to gather in dangerous places. Class 4 is for fibers which are in storage and not likely to be carried in air currents.

The motor designer does not have to work something out to handle every problem in Class 1 or in Class 2. He can pick a hard one or an easy one, or he can aim at something for which he knows he has a market. To let him do this there are a number of subclassifications.

Class 1 has (A) acetylene, (B) hydrogen and manufactured gas, (C) ethyl ether vapor, and (D) gasoline,



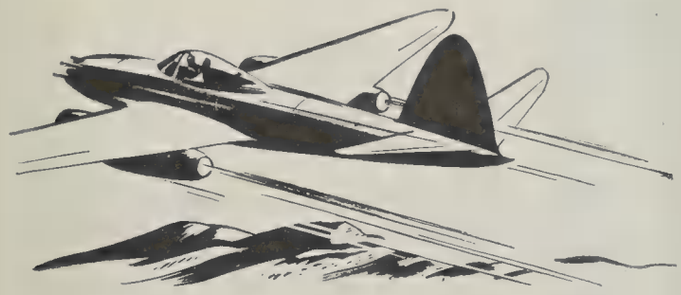
Here a deep well pump is operated by a vertical hollow-shaft motor, weather-proofed for permanent use outdoors



Coupled to a gear reducer for a paper mill drive, this 15-horsepower, direct-current motor is completely enclosed

THE YEAR THE TIDE TURNED . . .

1944 was the year of greatest advance in invention, science and industrial production in world history. Here is a part of that record as written by Westinghouse.



In the new field of jet propulsion for the Navy Bureau of Aeronautics, we developed the first completely American jet propulsion engine, which promises to produce more power, for its weight, than any of the European-designed engines now being built in this country.



Electric power plants on wheels . . we built and delivered 34 Westinghouse Power Trains, each a complete power plant on railway cars. By means of these remarkable trains, electric service can be "shipped" to liberated and devastated areas behind the fighting fronts.



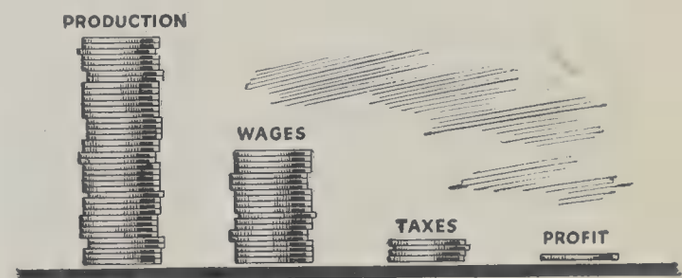
Aboard aircraft carriers . . new Westinghouse-designed elevators are in action. We found a way to get carrier planes to and from the flight deck faster, keeping it clear for flying operations. A development that has proved very important in getting more planes in the air quicker.



Against enemies even more deadly than the Jap . . a mighty weapon was developed by Westinghouse engineers, co-operating with the Army and the Department of Agriculture. The enemy . . . disease-carrying insects. Scourge of fighting men through the ages! The weapon . . . the Bug Bomb, no bigger than a can of soup, means sudden death to insect pests in 250 pup tents or 50 big bombers.



We stayed on our jobs, 115,000 strong . . . no major strike or slowdown has occurred in any Westinghouse plant since war began. 14,867 employees earned cash Suggestion Awards for new ways to increase production, cut costs. We employed 5,620 honorably-discharged veterans, many of them wearers of the Purple Heart. In addition to the big job of operating our own plants . . . Westinghouse operated 3 of the 7 great Navy-owned ordnance plants.



A billion dollars' worth of production and service . . . was delivered by Westinghouse to America in 1944. Nearly half the money we received went for wages. Less than 3 cents per dollar were earned as profit on what we did. We paid the Government 102 millon dollars in taxes. For each dollar's worth of goods and services delivered we kept only a little more than 2½ cents as net profit.



A promise for the future . . There is a lot to be done yet . . . and you can count on Westinghouse men and women to do their share of the war job as long as American men still fight anywhere. And when war is won, you can look to us for the best in electric appliances, radios, lighting, electrical equipment for industry . . . and for continued leadership in new fields.

Westinghouse Electric & Manufacturing Company,
Pittsburgh 30, Pa.

Westinghouse

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TED MALONE—Monday, Tuesday, Wednesday Evening, Blue Network
Tune in: JOHN CHARLES THOMAS—Sunday 2:30 pm, EWT, NBC

acetone, alcohol, and natural gas vapors, Class 2 has (E) metal dusts, (F) coal or coke dust, (G) grain dust. The higher they are on the list the harder they are to defeat; metal dust is the dust-proof motor's public enemy number one.

The motor manufacturers are accepting any challenge in which the market is big enough to provide good high stakes.

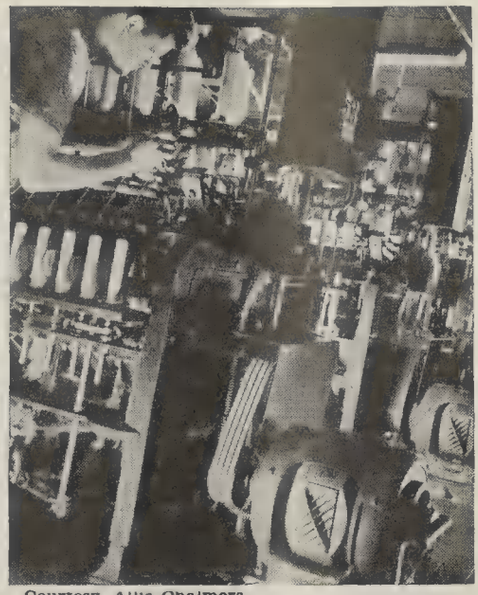
Take magnesium for example. The finer the magnesium dust or chip the greater its hazard. A lighted match can be held to a solid chunk of this metal and nothing will happen, but do not try that with a pile of its shavings. And magnesium, the lightest of commercial metals, is being used in such large quantities that hundreds of machine tools are cutting it.

A new type of motor is specially made to stand magnesium dusts and is good for any dust, metallic or otherwise. The cooling is not done by blowing air through the motor itself but by an external fan which blows air through vent passages which are in the case but do not penetrate to the electrical parts. These passages are straight; dust is not likely to lodge in them and if it does it is easy to clean out. The fan is of non-sparking bronze.

Another motor is hermetically sealed against dusts, gases, and fibers. It, too, depends upon casing vents. Types like this one come closest to being the universal answer to hazardous fumes and dusts. But they are not yet ready for everything—the case still gets too hot for some gases as it throws off the internal motor heat.

There are other tricks. On 400 horsepower and larger motors it can pay to keep the electrical parts filled with an inert gas. The pressure of the inert gas is always a little greater than atmospheric and if there is any leakage it will be of inert gas escaping.

Another method is to give the motor its own fresh air and exhaust piping.



Courtesy Allis-Chalmers

Textile mills now use lint-protected motors belted directly to machines

So long as those ducts do not leak, no explosive gases can get into the motor.

The motor manufacturers are out to make their products fool-proof and fool-resistant. The market is welcoming the new motors as fast as they appear. And in the future far more motors will be used because motors will solve far more problems.

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POWER EXCHANGE

Offers Economy Possibilities To Industry and Public Service

A NOTION which will not down is that of having industrial plants feed back power to the municipal or public utility lines during the hours when the industrial load is low and the home load is high.

Much of central power station cost is for "stand by" equipment which is idle except for a few peak hours every day. Factories have to pay for that. In most communities the industrial power bill is in two parts: the demand bill for the extra power needed to start up the machinery in the morning and for other emergencies, and the running-load bill for the much lower ordinary operating load. Often the power needed at the demand peak is more than twice that of the operating load.

The idea is that industries could use steam, gas, or Diesel engines to generate the extra power for their own demand peaks, then could use public-service power for the all-day operating load, and, finally, could run these engines and feed their generated electricity to the public-service lines during the evening hours when the household load is at its highest. By this means the public utilities could get rid of much of their equipment and power could cost less for everybody.

Using industrial power on public service lines would need only the development of a few simple synchronizing devices. In addition to its public economy, this method would rid communities of the fear that if any serious accidents were to happen to their public power stations their industries, hospitals, schools, and homes would be in a bad way.

CONVECTION CURRENTS

Make Heat Treatment More Accurate

HEAT treatment of metals is attaining high accuracies during this war. And one contributor to this accuracy is more skilful use of convection currents in heating and cooling.

An example of this use is the case in which parts to be cooled between hardening and annealing operations are placed in a pit filled with inert gas which will prevent oxidation. The parts are placed at the bottom of the pit and therefore the convection currents from the heat they exude cause heated gas to rise to the top. In a well-insulated pit the rate of cooling is governed largely by the difference in temperature between the parts and the gas which surrounds them and by the ability of the gas to absorb heat. By controlling the temperature at the top of the pit the temperature of the gases returning as convection currents to the bottom is controlled and the cooling of the parts is kept at the desired rate.

MORE MODELS

Made by Co-Operation Of All Departments

A NEW way of using models to develop products and speed production has crept almost unnoticed into the practices of industry.

Based upon the old axiom that "the blueprints cannot tell everything; they must be interpreted," the new method is to have the various parties associated with any development make models independently of each other and then compare them.

A machine-tool maker, for example, makes a wooden model of a special machine, the shop which designed the machine or is to use it makes another, and the two are compared. The usual result is a third model having features superior to both of the original ones—and thus months or even years of experimentation are eliminated.

Models may be made by the product engineer, the tool maker, and the production manager independently of each other, all based on ideas for a new product submitted by the sales department. When all four departments get together to discuss the models, the result is likely to be a product which will sell, contains all of the latest features, and can be produced at low cost and with little expense for tooling.

PRODUCTION TEAMS

Speed Plant Operations and Make Quick Changes Possible

ONE of the oldest tricks in the handling of men is proving to be one of the newest. The trick is to form permanent teams of two or more workers —just as carpenters, coal passers, and other hand laborers used to do before mechanization became so general.

The new method is to educate teams as teams instead of teaching men as individuals. The crew of three which is to serve a centerless grinder, for example, sits down before a motion picture showing themselves at their work, and later views another film showing the ideal method of serving the machine. If the machine is to be changed to a new task, the team is shown a film of the operation as performed by a crew that has been long acquainted with it. They are encouraged to talk with each other as the film progresses, making their own plans for best team play as well as asking questions of the instructor.

Soldering teams, welding teams, inspection teams—dozens of different crews are handled in the same way.

Taking Steel's Temperature

By Means of a Newly Developed Thermocouple Pyrometer, the Temperature of Molten Steel Can be Rapidly Determined Before It is Poured, Thus Making Possible Accurate Control of Quality and Uniformity of Finished Steels

THE FIRST practical and accurate way of measuring temperatures of molten steel up to 3200 degrees, Fahrenheit, in an electric arc melting furnace has been developed and put to everyday use by adapting and improving upon a British device. Metallurgical engineers at Rustless Iron and Steel Corporation have devised a platinum thermocouple pyrometer which measures the temperature of a steel bath before the heat is tapped from the melting furnace. The reading is recorded by an electronic instrument.

The new pyrometer goes a step beyond the optical pyrometer, which is limited to the measurement of temperature when the liquid steel is visible in the open and being poured. It measures the temperature of the steel in the melting furnace—even though the steel itself is covered with a layer of slag—at a time when steps can be taken to regulate and control the temperature. After the steel is tapped from the melting furnace, little or no temperature control is possible. The development thus makes possible an improvement in the quality and uniformity of steels.

The pyrometer consists of two interchangeable parts—an immersion head (a platinum and platinum-rhodium thermocouple encased in a fused silica tube mounted in a block of graphite) and a handle which is a 12-foot insulated pipe containing the wires leading to an electronic recorder.



A worker checks the big dial of the electronic device which records temperatures ranging from 2200 degrees up to 3200 degrees, Fahrenheit, at the Rustless Company's Baltimore plant

The operator of the device simply manipulates the immersion head, mounted on the pipe handle, through the door of the electric furnace and dips it into the steel bath. The exposed tip of the silica tube, which contains the thermocouple wires, is immersed in the bath and the graphite block is in contact with the metal, the slag layer, and the hot atmosphere of the furnace. The whole operation, which is automatically recorded, takes about 45 seconds.



At a safe distance, the operator of the thermocouple pyrometer inserts the immersion head into an electric arc furnace where, in 45 seconds, it makes an accurate temperature record

The instrument by which the measured temperature is recorded is equipped with a large pointer and dial calibrated in degrees Fahrenheit. This recorder is mounted conveniently near the furnace where it is easily visible to the melter responsible for the manufacture of the steel and to the man operating the thermocouple.

The new thermocouple, making possible the accurate measurement of steel temperature, provides the steel melter with the means of controlling one of the most important variables in the manufacture of steel. The practicability of the device, working as it does at temperatures so high that most materials are either softened or completely destroyed, lies in the speed with which the equipment measures and records the molten steel temperature. The electronic instrument responds so quickly to the temperature of the thermocouple that it is possible to immerse the unit into the molten steel, obtain a reading of the temperature, and remove the equipment from the melting furnace before the device is melted or destroyed by the intense heat.



Research engineers worked for five years to develop this thermocouple of platinum for recording the temperatures of molten metal accurately

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WOOD WASTE MATERIAL

Seen as Basis of New Chemical Industry

THE future prosperity of the wood industry depends upon the degree to which the raw-material wastage can be transformed into the manufacture of profitable chemical products. A chemical industry based on wood will have a greater chance of success if it is closely integrated with a complete forest products industry, including ownership of the forests as sources of basic raw material. This opinion was expressed recently by Dr. J. A. Hall of the United States Forest Service in *Chemical and Metallurgical Engineering.*

"Important wartime developments have shown new ways of utilizing lignin from the alkaline pulping processes

in the production of lignin-filled compressed paper goods with rather remarkable properties," says Dr. Hall. "This may develop into an outlet for large tonnages of recovered alkali lignin.

"Post-war developments may be expected to be in the direction of widely diversified uses for coniferous wood sugar in chemicals production and the use of hardwood sugar for similar purposes. Lignin from wood hydrolysis is promising material for the production of some chemicals already in mass production.

"The whole future of the industry based on impregnation of wood and paper with resin-forming chemicals depends upon cheap resin-forming chemicals," continues Dr. Hall. "Wood itself may prove to be such a source, especially if costs can be distributed over a broadly differentiated wood industry, integrated with the forest and within itself. Lignin also offers promising possibilities along other lines leading toward coating specialties and similar products.

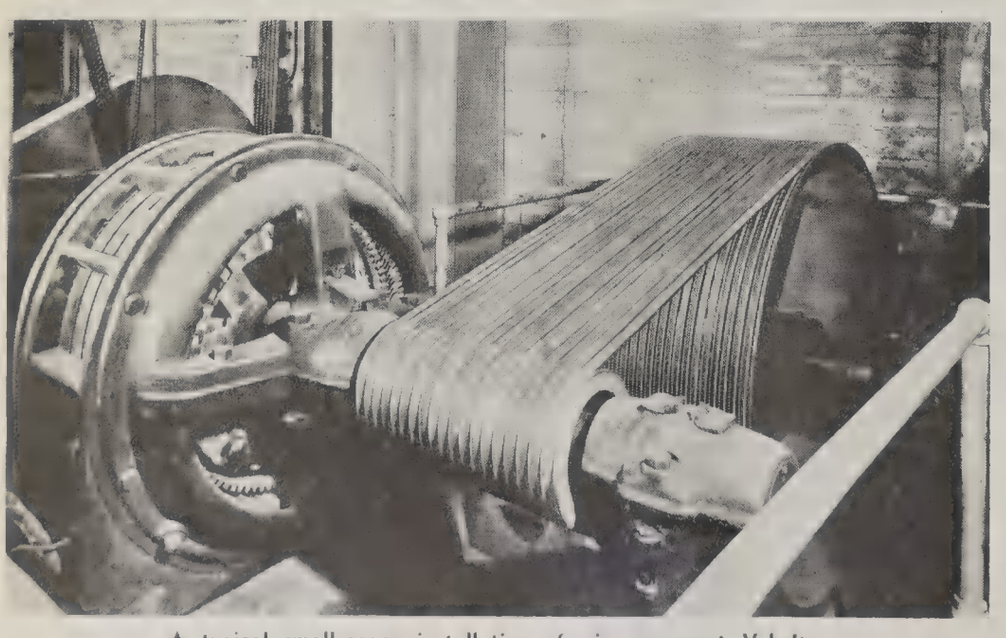
"Three characteristics that distinguish wood as a raw material for chemical engineering are (1) It is a perpetually renewable resource, of the same kind and in the same place. (2) Chemical wood can be a by-product of forestry, the principal product being lumber. (3) The methods used in harvesting the wood crop determine the nature of future crops."

V-BELTS

Replace Chain Drives
In Grain Elevators

ONE OF the newest utilizations of the wire grommet V-belt is its installation in one of the leading grain elevators of Duluth, Minnesota, where it has replaced a chain drive. Operators of the elevators wanted to change the drive to V-belts, but installation of the conventional types would have required cutting out the floor to permit larger diameters or moving machinery and concrete bases to allow wider sheave face widths, according to the B. F. Goodrich Company.

Using wire grommet V-belts, no more space is required than for the chain drive. All chain drives on the elevator are being replaced by wire grommet V-belts as they wear out.



A typical small-space installation of wire grommet V-belts

SYNTHETIC POLARIZERS

Made from Sodium Nitrate
By Use of Mica

A METHOD for manufacturing certain optically important crystals larger than any nature has ever been known to produce involves an ingenious manipulation of atoms which provides a new and important tool for optics engineers. Key to the new method is the use of mica as a means to control the atomic arrangement required for the production of large optical crystals.

The design of most military and other optical instruments is today based principally on the fact that a beam of light bends when it passes from one optical material to another. The new method, developed by Dr. Cutler D. West and his associate, Frederick J. Binda of the Polaroid Corporation's research staff, permits large-scale production of an optical crystal which can be cut in such a way as to split a single beam of light into two bent beams, thus making the familiar optical phenomenon of double refraction widely available to optical engineers.

Polarizing prisms can be made of these crystals. The prisms polarize light over a wider range of the spectrum than most other synthetic polarizers.

Scientists have known for years that large crystals with the optical properties of calcite might be produced synthetically from molten sodium nitrate. The problem, however, has been to devise a means for controlling the arrangement of the atoms of the molten mass when the temperature is reduced and it starts to harden. With such control, the crystal ends up in an optically useful form. But with no control exerted on the atoms of the melt, it has a natural tendency to harden in an optically impractical form. No efficient control was known before West disclosed that mica provides the key to the problem of how to arrange the first atomic layer. Once the first atomic layer of the melt has hardened in the correct orientation, subsequent layers orient themselves automatically in the desired manner.

Mica is used because its atomic surface, dimensionally like the atomic surface of a sodium nitrate crystal, fits like a peg and hole arrangement with the atomic surface of the melt. Another advantage of mica is that the potassium atoms on its surface, arranged like the sodium atoms on the surface of the melt and similar in size, presumably dissolve when mica



Dr. West and Mr. Bunda measuring a large crystal of sodium nitrate produced by a new manufacturing method

is placed on top of a sodium nitrate melt. When they dissolve, holes occur in their place. The sodium atoms of the melt then fall naturally into these submicroscopic holes. Under controlled temperature the surface of the melt in contact with the mica starts to harden first. Here, the mica corresponds to the thin skin of ice which forms first on the surface of a pond and then slowly grows downward into a single crystal. With the sodium atoms thus controlled in their arrangement on the surface of the mica, the rest of the atoms of the melt are oriented in the form of a large optically useful crystal as soon as the entire melt hardens. The area of the crystal which can be grown by the new method is limited substantially only by the size and quality of the mica obtainable. Mica of good surface quality is often found in areas three feet in diameter.

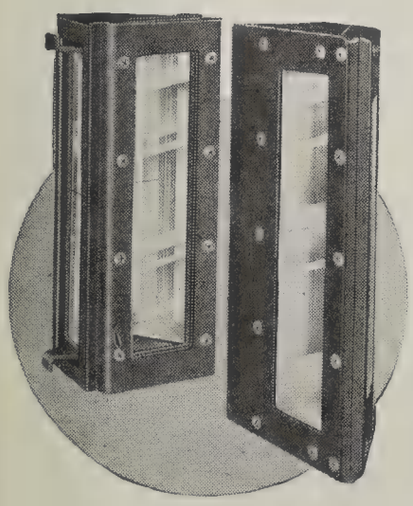
MADE FROM PEANUTS

New British Fiber
Blends with Wool

ARDIL, a new substitute fiber, is not merely a substitute fiber competitive with wool, but has complementary uses, enabling lighter woolen fabrics to be manufactured. Preliminary experiments were conducted by the Bradford (England) Technical College, and trials were then arranged on a commercial basis with textile firms.

The vegetable protein used in the production of Ardil is extracted from the peanut with dilute alkali. It is then precipitated and made into a spinning solution which is extruded through minute holes of a spinnerette into a

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ACHROMATIC OBJECTIVE LENSES with F.L. of 193 mms. Have wider diameter than those used in Army's 7 power binocular. Excellent for telescopes. Diameter of edged lenses are about 52 mms.
Stock #6064-S—Edged and Uncemented—Price $1.75

SILVERED TANK PRISMS
90-45-45 degree, 5¾" long, 2⅛" wide, finely ground and polished. Would normally retail from $24 to $30 each.
Stock #3004-S ..... $2.00 each Postpaid
(Illustrated booklet on Prisms included FREE)

PLAIN TANK PRISM
Same dimensions as above. This one is excellent for projecting all the colors of the spectrum. Worth $24 to $30.
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This is the most sensational bargain we have ever been able to offer.

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An exceptional opportunity to secure a large variety of optical pieces (seconds) in varying stages of processing — from raw optical glass to partially finished. Most pieces have been molded, some finished on one side. Diameters up to at least 3 inches. Good variety of prism blanks included, bulk packed. Refractive indexes from 1.5110 to 1.6490 but not identified. Most crown glass — some flint. Sold "as is" but with our usual guarantee of full satisfaction or money refunded. Excellent for educational uses; for practicing and learning optical grinding and polishing. Stock #703-S 5 lbs. (minimum weight) $5.00 Postpaid. (Most shipments average weight over 7 lbs.)

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REDUCING LENS SET
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Two big Lenses, 1¾" and 2" in diameter. Will make objects look smaller than they actually are.

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Stock No.	Dia. in mms.	F.L. in mms.	Comments	Price
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6019-S	15	41	Cemented	60c
6021-S	18	49	Cemented	60c
6023-S	25	95	Cemented	75c
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USES: —Use these Lenses for making Projecting Lenses, Low Power Microscope Objectives, corrected Magnifiers, substitute enlarging Lenses, Eye-Piece Lenses, Microphotography, gadgets, optical instruments, etc., etc.

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KELLNER EYE-PIECE LENSES with F.L. of 27.5 mms. Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. These are excellent for all sorts of telescopes.
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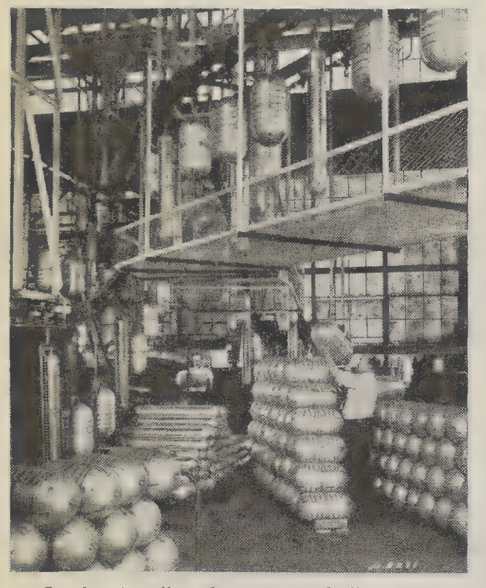
coagulating bath. The resulting fine filaments can be cut to any required length and may be mixed with wool, cotton, or rayon, and yarns may then be made on the worsted, woolen, or cotton systems according to the type of fiber desired.

When mixed with cellulose, Ardil is said to add warmth, fullness of hand, resilience, and crease resistance to the finished fabric. It dyes like wool and has an added advantage in that moths will not attack it.

OXYGEN CYLINDERS

Are Now Explosion-Proof When Pierced by Cannon Shell

OXYGEN cylinders designed to withstand cannon fire without exploding are now being used on American war-planes throughout the world. These cylinders, developed and now being made in mass-production by The Firestone Steel



Production line for non-exploding oxygen cylinders made of stainless steel

Products Company, are designed for use on every type of military aircraft from the Superfortress to the smallest fighter ship.

Designed after the fire power of fighter planes was increased to include cannons, the stainless-steel cylinders will not explode even when pierced by a 20-millimeter shell. The protection against shattering built into the new cylinders is of vital importance, for if the cylinders were not explosion-proof the oxygen which preserves life during flights and aerial duels at high altitudes might become a deadly enemy.

An ordinary cylinder filled with oxygen compressed to 400 pounds to the square inch exploded with terrific force when pierced by bullets during tests at the beginning of the war.

HEAT SEALING

Expedited by Use of Vacuum Cleaner

AN ORDINARY household vacuum cleaner is being used in the shipping room of an electrical manufacturing company to help wrap vital war products going to all parts of the world. The special sealer consists of an electric heating element inserted on two sides of a vise-like clamp. When the heat is applied to the specially processed vapor-proof bags, the seal is quickly and effectively made.

Before heat is applied, all air is withdrawn from the package by an Apex cylinder type cleaner with a reduced nozzle. Then the scissors-like clamps seal the open edge.

NEW LABORATORY

Built for Study of Jet-Propulsion Fuels

DESIGNED specifically for the study of fuels and lubricants for jet-propelled aircraft, a new laboratory has been built and put into operation at Wood River, Illinois. Combustion of such a radically new character as takes place in a jet unit requires new basic research, and completely new studies of burning characteristics of possible fuels have been undertaken. In addition to surveying fuel requirements, and determining characteristics and qualities of fuels most efficient for jet-combustion, the laboratory is also at work developing new experimental apparatus for further use in this type of research.

ALL-WELDED ENGINE

Proves Economical in Oil Field Service

AN EXAMPLE of the benefits possible through changeover to welded design is found in a new all-welded gasoline engine for oil-field service which has over 25 percent less weight, lower initial cost, easier portability, and lowered maintenance as compared with engines of cast-iron construction. According to The Lincoln Electric Company, suppliers of the welding equipment used in fabricating the newly designed engine, the unit is a four-cylinder type operating on either natural gas or gasoline and is used for drilling oil wells by the cable tool method. It is operated at a speed of approximately 500 revolutions per minute when drilling and 1500 revolutions per minute when bailing a well or



A vacuum cleaner withdraws the air: the heating unit seals the package

pulling tools. The unit has a rating of 120 brake horsepower at 1200 revolutions per minute. Cylinder bore is 4⅞ inches with a piston stroke of 7 inches.

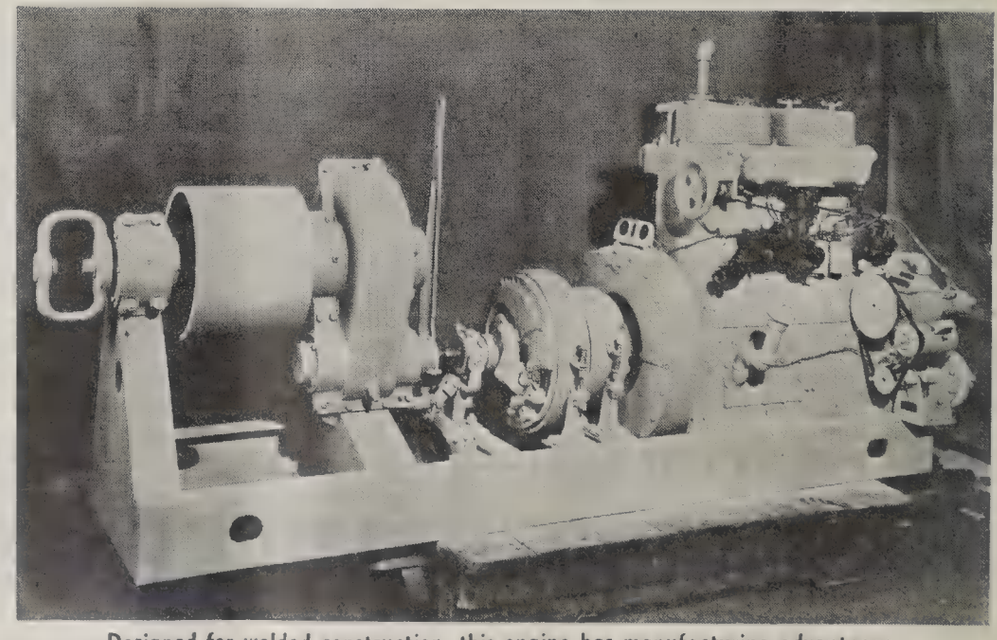
According to the manufacturer, Buffalo Gasoline Motor Company, welded construction offered them manufacturing advantages that eliminated costly foundry delays and expensive pattern making and maintenance.

ULTRA-VIOLET RAYS

Absorbed by Chemical Used in Goggle Lenses

MORE than 99.9 percent of the ultra-violet radiation of the sun is absorbed by a synthetic chemical used in the manufacture of plastics goggle lenses. The chemically treated plastics is distinguished by the combination of stability, high transmission to visible light, high ultra-violet absorption, and non-fluorescence when ultra-violet light strikes it.

Discovery of the ultra-violet absorbing properties of the chemical is noteworthy because the chemical can be used in conjunction with the manufacture of plastics now employed as goggle lenses and as filters in military visual instruments such as range-finders and gunsights. The chemical is classified as an azine.



Designed for welded construction, this engine has manufacturing advantages



Here's where you stand today!

Look ahead a year or two...for your own sake.

Over on the dark side is this: Every unnecessary thing you buy helps shove the country one step nearer inflation and the bad times that come in inflation's wake.

Over on the bright side is this: Every single cent you save helps move you and your country one step nearer the kind of prosperous, happy, post-war America you want.

Okay—you're human. You're thinking mainly about yourself.

YOU SHOULD. Because if every man Jack (and every girl Jill) buys nothing he can get along without . . . (avoids Black Markets and "just-a-little-above-the-ceiling" like the plague!) . . . pays off the mortgage or any other debts . . . takes out more insurance . . . builds a healthy sock of savings . . . buys and holds more War Bonds—inflation will stay away from our door.

And Jack and Jill will be in a sound position no matter what times come.

Maybe you ought to clip this signpost and paste it in your pocketbook as a reminder that you can BUY your way to bad *times. Or you can SAVE your way to* good *ones.*

That's where YOU stand today.

4 THINGS TO DO to keep prices down and to protect your own future!

1. Buy only what you really need.

2. When you buy, pay no more than ceiling prices. Pay your ration points in full.

3. Keep your *own* prices down. Don't take advantage of war conditions to ask more for your labor, your services, or the goods you sell.

4. *Save.* Buy and hold all the War Bonds you can afford—to help pay for the war and protect your future. Keep up your insurance

HELP US KEEP PRICES DOWN

A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in cooperation with the Magazine Publishers of America.

New Products and Processes

THIN RECORDS

Run 15 Minutes, Take Up Little Room

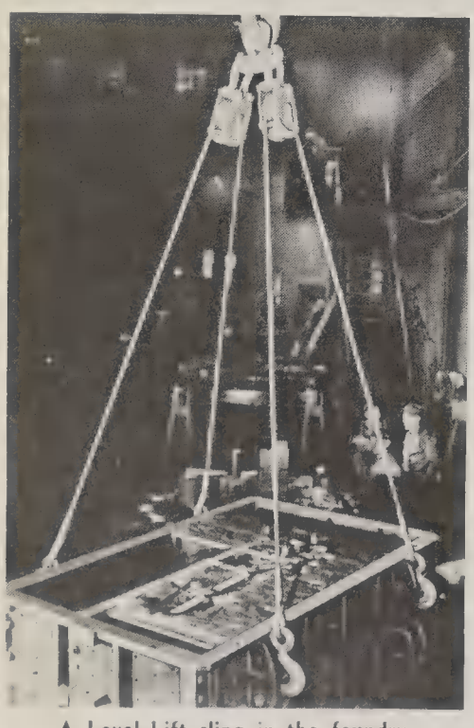
A RECENT development in plastics and electronics is a wafer-thin Vinylite plastics record, only seven inches in diameter. Each side of the disk will record approximately 15 minutes of dictation. It is light enough to be mailed in an envelope at regular letter postage rates. Made from Vinylite plastics sheets, these records can be bent, rolled, dropped, and written on with a pencil without harming the sound track. They can be stored indefinitely, without warpage, breakage, or distortion, in an ordinary filing cabinet—100 disks to the inch—and played back at least 100 times.

The Army and Navy use the equipment in vital communications work and it has been used extensively by government bureaus, in hospitals, and radio stations. After the war, this new development of Sound Scriber Corporation can be expected to take much of the drudgery out of salesmen's reports, and out of the clerical requirements of field men, investigators, inspectors, reporters, and the like.

SAFE SLINGS

Automatically Adjust Themselves to Load

THE COMPLETE line of Macwhyte Caldwell "Level-Lift" slings now includes ¾ ton, 1½ ton, 3 ton, and 6 ton capacities. Their operation is simple. After the light-weight block containing wire rope is put on the crane hook, the crane operator spots the crane hook over the approximate center of gravity of the load and the floormen attach the sling to the load.



A Level-Lift sling in the foundry

The crane operator then applies the power to lift the load and, as the crane hook is lifted, the rope automatically adjusts itself through the "Level-Lift" block. In so doing, one sling leg of rope becomes longer than the other and, as the weight of the load pulls on the wire rope, the sheave in the block pulls down against a brake which prevents slippage. The load is then lifted level.

TOUGH FILM

Can Be Used in Sheer Fabrics or Shoe Soles

RAINCOATS so light and thin that they can be slipped into a woman's hand-bag and inexpensive awnings that neither fade nor wear out are two of hundreds of post-war products to be made from a unique new material announced by The Firestone Tire and Rubber Company.

The material is a plastics film which can be made as thin as a hair and as soft and flexible as fine clothes, yet which is comparable in strength to metals.

Lampshades that can be cleaned with soap and water, aprons that can be washed and dried exactly as are the dinner dishes, and portable bathtubs that can be folded like Army cots, are a few of the other additional products that can be made from the new substance.

The film is the latest member of the Velon plastics family, which already has been used in dozens of important war jobs ranging from screening for American jungle fighters to lenses for gas masks. Eventually it will be used for a wide variety of products ranging from woven fabrics sheerer than the finest silk to shoe soles tougher than leather.

The film is elastic, flexible, odorless, tasteless, non-soluble in water, and particularly resistant to scuffing, snagging, and tearing.

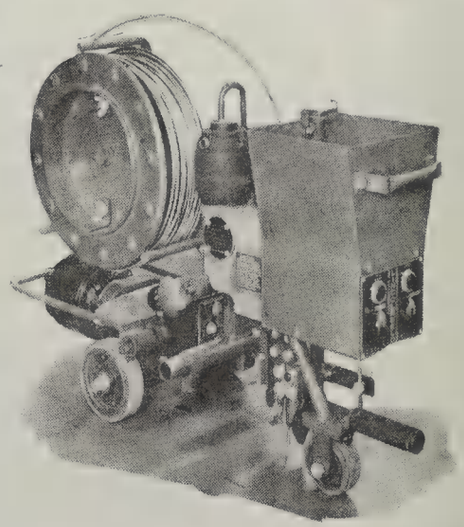
IMPROVED WELDING

Said to be Faster Than Other Automatic Methods

AUTOMATIC arc welding equipment developed to meet the need for a more fool-proof and easier applied process, has established its practicability over a period of several years. During this time many units have been successful in welding a variety of products, including machinery bases and beds, motor and generator frames, ventilating fans, tanks and pressure vessels of all kinds, LST landing craft, and many parts used in the prefabrication of ships, railroad cars, and other heavy equipment.

The method is designed for use with direct current, utilizing a bare metallic electrode which is fed through a granular flux deposited on the joint to be welded. Sufficient flux is applied to completely blanket the arc and the molten metal. The unfused flux is reclaimed for further use.

The new process, called Lincolnweld by the Lincoln Electric Company, uses extremely high current densities. For example, ⅛-inch diameter electrode may carry as much as 650 amperes. This produces greater penetration and permits smaller cross section of weld metal with resulting saving in cost and reduced warpage and distortion.



Motor-driven tractor unit that uses the new high-current welding process

Users report that the new method is less sensitive to scale and moisture than conventional automatic welding methods. This eliminates or reduces plate cleaning prior to welding. In extreme cases of scale, buffing with a power wire wheel usually provides sufficient edge cleaning; grinding and sandblasting might have been required formerly.

ELECTRONIC CONVERTER

Used for Industrial Induction Heating

DEVELOPED to fill out the low frequency range of electronic equipment required in the growing field of induction heating applications, a new mercury-arc converter electronically changes power at commercial frequencies of 60 to 25 cycles into 1000 to 2000 cycle power. The mercury-arc type of frequency changer is particularly suitable for supplying power for forging, melting, and metal treating applications where large masses of metal or metal parts must be efficiently heated with this power at kilowatt capacities of 250, 500, 1000, and higher.

Two highly successful applications of the new converters have been made in the past year, one being a 300 kilowatt unit in a forge plant, and the other a 250 kilowatt unit in use in the melting

section of a brass foundry. The units, made by Allis-Chalmers, are quiet in operation and require no ventilation or air-filtering, since they are water-cooled. In addition, high capacity mercury-arc converters offer no vibration problems, making heavy and expensive foundations unnecessary.

ODORS

May be Combatted In Nine Ways

THERE are many different ways of attacking problems of offensive odors in the air, and no one of these provides the answer to every odor problem, according to an article appearing in *The Givaudanian*, organ of Givaudan-Delawanna, Inc., manufacturers of aromatic materials and pioneers in the field of odor chemistry.

The article points out that numerous problems arising out of a desire to overcome the objectionable odor in different buildings have been studied in the past, and it is expected that, in the post-war world, this will become a field of increased interest to many industries.

The methods for deodorizing air in buildings are based upon nine separate theories. They are listed as oxidation, alkalization, adsorption, antisepsis, washing action, chemical combination, electrostatic precipitation, catalysis, and reodorization. Each of these methods is usable for a different purpose and no one method is usable for all purposes. A short summary of each theory is given:

Oxidation: This involves converting an odor of unpleasant character to a pleasant or neutral one by oxidizing the chemical substance responsible for the bad odor. Typical oxidizing agents are potassum permanganate, hypochlorous acid, and ozone.

Alkalization: Alkaline reacting substances such as borax, ammonium carbonate, lime, and trisodium phosphate are frequently suggested as components of solid mixtures, possibly with the thought that the unpleasant odor to be overcome is a volatile acid. Thus alkalies are helpful in dealing with butyric acid of limburger fragrance or with caproic acid, which smells like a goat.

Adsorption: Gases and vapors responsible for unpleasant odors can frequently be caused to collect at the surface of porous materials. The three most important adsorbents are activated carbon, activated alumina, and silica gel. The activation consists in providing these materials with a maximum surface area. Carbon and silica gel are often used to adsorb odorous gases in refrigerators and in air conditioning systems.

Antisepsis: This is based on the fact or belief that the unpleasant odor is generated by microorganisms such as bacteria, molds, or fungi. Phenol, metallic salts, and formaldehyde are typical examples of substances employed to accomplish deodorization by destroying the organisms responsible for the odor. The germicidal action of formaldehyde depends also on its exceptional chemical reactivity. It represents an intermediate stage of oxidation between methyl alcohol and formic acid and could therefore play the part of either a reducing or of an oxidizing agent. It combines with amines and related substances to form odorless compounds known as Schiff bases. Sometimes it acts as a methylating agent.

Washing action: When air laden with odorous particles is forced to traverse a solvent such as water, alcohol, glycerin, or mineral oil, the odorous particles may dissolve in the liquid, leaving the emergent gas odorless. This is a washing or "scrubbing" action.

Chemical combination: Special cases of chemical combination have been mentioned as in the case of formaldehyde and alkalis. Many reactions which would take place very slowly, or not at all, under laboratory conditions may be realized under conditions of extreme dilution such as prevail where large quantities of air are deodorized. For this reason reactions which strike a chemist as unlikely, or even unreasonable, may actually come to pass in actual practice.

Electrostatic precipitation: This is primarily a dust removal operation, but since the dust may itself be odorous or may carry odorous gases by adsorption, it can be readily seen that electrostatic dust removal is an efficient way to get rid of certain odors.

Catalysis: According to electronic chemical theory, catalysts are looked upon somewhat as members of a bucket brigade passing along the electrons



Why 109 Kinds of Optical Glass?

Bending light to the will of man, making it accomplish miracles, this is the job that optical glass does.

Creating the required types of glass, and adapting them to the thousands of precision operations they are to perform, is the task of Bausch & Lomb, America's large scale producer of optical glass and the only company currently producing 109 kinds.

Many of these glasses may look alike, but to the optical expert each is different. That difference is marked by specific qualities of refraction, dispersion, and transmission.

Only by having available all of these types of glass . . . and the ability to create new types when needed . . . has Bausch & Lomb been able to meet the optical instrument needs of science and industry in times of peace . . . the needs of our armed forces for highly precise military optical instruments. Bausch & Lomb Optical Co., Rochester 2, New York.

BAUSCH & LOMB

ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry, and Eyesight Correction and Conservation

(buckets) and thereby speeding up chemical reactions.

Reodorization: This approach may take the form of overpowering an existing unpleasant odor with a pleasant odor; or, more subtly, it may involve utilizing the unpleasant odor itself as a component part of a complex mixture, the total effect of which is pleasant. Sometimes a considerable number of different essential oils and odoriferous chemicals are used to accomplish this. Perfumed deodorants in the form of wall disseminators, hand sprays, and wicks have long been used. The successful job done in the insecticide field with aerosol bombs suggests that, after the war, perfumed deodorants may possibly be dissolved in Freon and sprayed by merely turning a nozzle.

WELDED TRUSSES

Are Easily Adaptable To Different Loadings

A NEW design for welded trusses of standard 50, 60, 70 and 80-foot lengths, in which, for the first time, H-sections with their webs in a vertical plane are used throughout without gusset plates, has been adopted by The Austin Company.

This truss is readily adaptable to different loadings by simply changing the weights of the beams used for the various truss members, according to J. K. Gannett, Austin vice president and director of engineering. By keeping the depths of the individual members constant, these variations require no changes in shop details or fabricating jigs.

As the top chord is a wide flange beam, it can carry purlins at a variety of spacings without regard to panel points, and is also adaptable to continuous uniform loading. Similarly, the bottom chord can carry loads at any point and can be used, itself, as a monorail.

A "natural" for welding, shop fabrication on a 50-foot truss requires a total of 41 lineal feet of fillet weld, all of which is accomplished by down welding. The H-sections are assembled in a jig, tack-welded, and welding is completed with the truss in a vertical position.

Because it is fabricated completely from rolled members which are simply cut to desired lengths, no splitting, blocking, slotting or chipping is necessary. The only raw cut edges are closed by the welds, so that only the smooth, hard, rolled surfaces are exposed, which gives the truss a maximum of corrosion resistance.

In full-size load tests on two 50-foot trusses of this new design made at the fabricating shops of The Austin Company more than a year ago, failure occurred under a load which was 253 percent of the design load, at which point an end vertical buckled. Despite the distortion of the truss when it collapsed, not a single welded connection failed.

The behavior of the truss under a heavy overload was impressive and is attributed in large part to the fact that the lines of action of all members lie in one plane, as well as to the concentricity and symmetry of the end connections of the truss members.

Following the tests, trusses conforming to the spans in widest use were designed and jigs set up for their manufacture. During the final quarter of 1944, trusses of this type were fabricated and shipped to plants in five widely separated localities, one of which involved an area of 100,000 square feet.

Experience in the field demonstrated that the new trusses are much stiffer than other welded trusses, and that they make steel erection work much safer. Structural iron workers, for instance, found that they could work much more easily on both top and bottom chords. This was particularly true of the bottom chord, where the flat upper flange provides a safer and more comfortable surface than the cut vertical edge found in most trusses. The flange not only provides an excellent walking surface but also a good seat for men while working on bolted, riveted, or welded connections.



Fabricating one of the H-trusses described above

HYDRAULIC PUMP

Has High- and Low-Speed Pistons

A TWO-SPEED foot pump for pressures up to 10,000 pounds per square inch has as an advantage an automatic change speed feature. The pump has two pistons—one a high-speed, low-pressure piston; the other a small, slow-speed, high-pressure piston. Up to 1000 pounds pressure both pistons pump oil; at 1000 pounds the high-speed, low-pressure piston automatically cuts out and higher pressures (up to 10,000 pounds) are easily developed by the small high-pressure piston.



Self-contained hydraulic pump

Many applications calling for hydraulic pumps require first that a large volume of oil be delivered, and second that high pressures be developed. A typical example is the furnishing of power to a hydraulic cylinder where the ram must be extended a large portion of its total travel before it contacts the work and then high pressure must be applied for the final operation. This pump will provide the fast travel at low pressure, thus minimizing the delay in bringing the ram to the work and, without an increase of effort on the part of the operator, will develop high pressures for the actual work. Maximum pressure can be pre-determined by the adjustment of a relief valve.

GAS PURIFIER

Utilizes Palladium as Catalyst

IN LABORATORY tests and under practical working conditions a gas purifier that utilizes the precious, but unrestricted, metal palladium as a catalyst has shown its efficiency in removing oxygen from such gases as hydrogen, nitrogen, argon, and neon. Gases of extremely high purity—that is, with less than 20 parts of impurity in a million—are thus obtainable, it is claimed.

While uses of the new Deoxo purifier are many, it is expected to be especially valuable in the manufacture

of radio and radar tubes. It is also useful for heat treatment of alloys, in powder metallurgy, and in research laboratories using pure gases.

The unit will be produced in two sizes. Both are compact, containing the catalyst encased in metal cylinders provided with intake and outlet valves through which the gas is passed. One, with a capacity of 200 cubic feet of gas an hour, is designed for laboratory and limited production use. The other, for general plant operation, is constructed for wall mounting. Its capacity is 1000 cubic feet of gas an hour. Both units will handle pressures up to 50 pounds a square inch.

The new Deoxo unit requires no external heating since it employs a new type of palladium catalyst efficient at room temperatures. It requires no warming up or cooling down period before and after use. Flow resistance is almost negligible and, it is claimed, will not change with use. It requires no maintenance and present indications are that, when used on cylinder gas, it should last indefinitely.

RUST-PREVENTING

Oil Keeps Radiators and Cooling Systems Clean

A COMPOUNDED oil and rust preventive which emulsifies quickly with water or any anti-freeze is claimed to keep radiators, water jackets, and cooling systems clean and to prevent rust and corrosion. The new oil, called Gibraltar "Rad-Treat," will also lubricate packing glands in pumps, and at the same time prevent shrinking and glazing of packing. When caustic solutions are used to flush out a radiator, it is recommended that Rad-Treat be added afterward in order to neutralize any acid condition produced by the caustic.

THIOKOL POWDER

May Be Molded And Vulcanized

MOLDED synthetic rubber parts with good resistance to solvents, greases, oils, fuels, sunlight, ozone, and atmospheric oxidation are now possible through the use of a new molding powder. Vulcanizing at 300 to 360 degrees, Fahrenheit, to form a resilient elastic solid, the new powder has proved itself an excellent material for compounds which are required to remain flexible at temperatures below —50 degrees, Fahrenheit. It remains serviceable to temperatures in excess of 220 degrees, Fahrenheit.

Believed to be an excellent material for a wide range of industrial parts such as washers, valve seat disks, diaphragms, gaskets, grommets, and so on, the new Thiokol molding powder can be compounded to obtain finished parts with a wide range of hardness.

In considering the properties of articles molded from this powder, they should be thought of in terms of soft vulcanized rubber rather than of hard rigid plastics. For example, rigid plastics display tensile strengths of from 1000 to 10,000 pounds, with elongations up to 1 percent, while soft rubber goods fall into the tensile range of 200 to 3000 pounds per square inch with elongations of from 100 to 1000 percent. The physical properties of the compounds made with the new molding powder are within the range normally considered satisfactory for most rubber mechanical goods applications.

PEANUT MEAL

Has Wide Potential Use If Properly Processed

NEW studies opening broader potential industrial uses for peanut meal are described in a recent issue of *Industrial and Engineering Chemistry.* Pressed peanut meal now is used almost exclusively as feed. The new work indicates that by proper control the peanut oil can be removed without destroying the protein values of the meal, thus making the product available for new industrial uses.

The work was done by T. D. Fontaine, Carolyn Samuels, and George W. Irving, Jr., of the Southern Regional Research Laboratory, United States Department of Agriculture.

"For many potential industrial uses," they said, "it is essential that the protein constituents of peanut meal be readily extractable, and that the extracted protein be substantially undenatured."

Customary treatments of removing the oil by commercial hydraulic pressing vary in severity, "but are usually



A smooth running installation of EXACT WEIGHT Sacking Scales in the Superior Fertilizer Company, Tampa, Florida.

Chemical Food for Hungry Acres....

The individual generally thinks of war goods in terms of ships, guns, shells and aircraft. These are of course the actual tools employed against the enemy and EXACT WEIGHT Scales by the thousands are used in all these operations of war materials manufacture. Yet fertilizer — lifeblood for depleted soil is still another war job . . . an important job, for without productive soil to produce food no war machine will function for long. Fertilizer is but one of the many free flowing chemicals packaged by EXACT WEIGHT Sacking Scales. Production men with such problems should write for details covering this necessary equipment.

INDUSTRIAL PRECISION

Exact Weight Scales

THE EXACT WEIGHT SCALE COMPANY

60 West Fifth Ave., Columbus 1, Ohio

Dept. Ad. 783 Yonge St., Toronto, Canada

sufficiently drastic to denature the protein considerably."

Their studies indicated that "critical denaturing temperatures for peanut protein are above 118 degrees, Centigrade, (dry heat) and above 80 degrees at 100 percent relative humidity. Since there appears to be little need for excessively high temperatures and moisture contents to rupture the oil cells of the peanut, it would seem advisable to employ in the mill the lowest moisture content and lowest temperature compatible with adequate oil removal."

FLUORESCENT FIXTURE

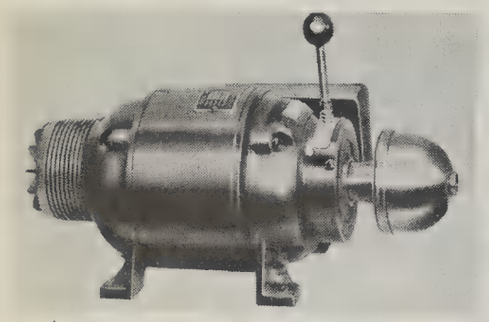
Has 93-Inch Lamp
That Does Not Flicker

COMMERCIAL lighting fixtures employing 93-inch fluorescent cold cathode low voltage lamps are now available along with assemblies for continuous line lighting. These "Simplicity" units are equipped with the 10,000 hour "Colovolt" lamps which are instantaneous in starting and do not flicker. The General Luminescent Corporation, which makes these units, states that long life expectancy may be realized, even when the lamps are constantly turned on and off.

POLISHING LATHE

Holds Odd-Shaped
Parts by Vacuum

SUCH parts as oil-can bodies, spun shapes, and flat stampings, which cannot be held by chuck or collet, are held firmly in a new polishing lathe which generates its own vacuum, without piping or glands; starts, holds the work,



A vacuum pump is the secret of this polishing lathe for odd-shaped parts

stops instantly, and releases the work rapidly for low cost production. All work is held firmly for polishing, burnishing, and many other operations. This "Vacuum Grip" lathe is made by the Crozier Machine Tool Company.

SAND IN GREASE

Is Important Ingredient
Of Silicones

IN ITS natural state sand is the cause of millions of dollars worth of damage to electrical equipment. Combined with coal, brine, and oil to create materials called silicones it has become a vital component of soft greases that neither harden at —40 degrees nor melt at 400 degrees, Fahrenheit. It has also become an intrinsic part of fluids with similar properties, yet as thin as water, and a basic ingredient of resins and varnishes which, when used as insulation, stand up under tremendous heat.

In testing silicone resins and varnishes, Westinghouse engineers found three possible major benefits: (1) because of silicone insulation, resistance to heat and reduction in size and weight of electrical equipment can be made for a given output; (2) greatly increased life can be obtained in the same size and weight; (3) machines with silicone insulations may be placed in operating locations where surrounding temperatures are higher than heretofore possible.

Discussing the silicone greases, the engineers said that "a translucent silicone grease of petrolatum-like consistency has been developed for use as a lubricant for ignition cables to reduce cutting of the insulation by electrical overcharges and permit easy wiring of ignition harnesses. Although a soft grease, it has the unusual property of not melting under heat. This material is inert and oxidation resistant, has no solvent effect on synthetic insulations or rubber and tends to prevent the hardening of these materials when heated in contact with air.

"Other silicone greases under development are being used for lubricating ball and roller bearings. One type can be used at temperatures as low as —76, Fahrenheit, and has high temperature stability at least as good as the best available organic greases. Another type is showing stability in lubricating ball bearings several times as great as organic greases at the same temperatures."

HOT CROPPER

Uses Oxy-Acetylene Torches
To Effect Economics

MADE-TO-MEASURE alloy steel blooms and billets are now being shipped from A. M. Byers Company, as a result of the installation of a new hot cropping machine at one of the company's plants. The machine, especially designed by Air Reduction Corporation, cuts blooms and billets by means of twin water-cooled torches using the oxy-acetylene process.

Previously, shearing on sizes up to nine by nine inches was practicable, but on larger sizes the entire bloom or billet was shipped. This created a special cutting operation at fabricating plants as well as a scrap disposal problem there. The hot cropper can cut to length all sizes up to 24 by 24 inches, achieving economy in shipping and permitting Byers to retain scrap of known analysis for its own use.

PLASTICS SLIDE RULE

Is Circular in Form
And Long-Wearing

A SLIDE rule that will remain accurate under extremely rough handling, which can be immersed in water, or exposed to greases and oils, without impairing its usefulness, is fabricated from "Vinylite" plastics by Tavella Sales Company. Virtually unbreakable and dimensionally stable even after long periods of time, the rule is circular in form, contains all of the features of the traditional oblong rule within its six inches of diameter, and, in addition, permits a multiplication-division table 13-1/8 inches long as against 10 inches on the regular type rule.

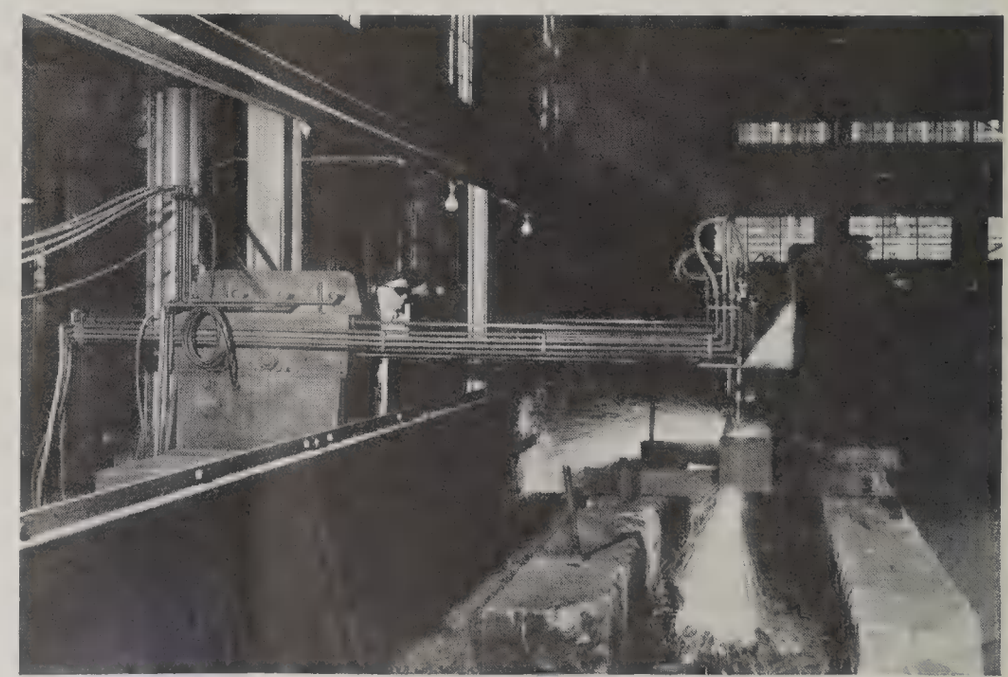
CROOKED GUN BARRELS

Straightened by Skilled
Hand Operation

DURING machining and drilling, some of the barrels used in Garand rifles and Winchester carbines become slightly curved. Others develop a number of curves. Unless such "kinks" are removed, the gun is so inaccurate as to be useless.

Barrels are straightened in a hand-operated press in which the curved section of the barrel is held between two dies and the kink literally pushed out by a third die. This die is controlled by a heavy spoked iron wheel similar in appearance to a ship's steering wheel.

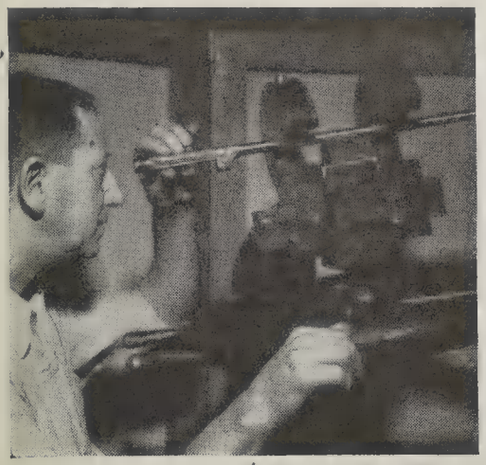
The operation, although it seems



Twin oxy-acetylene torches cut huge billets quickly and economically

simple, is extremely difficult and is entrusted only to experienced barrel-straighteners who have been doing this work for many years. At the Winchester Repeating Arms Company, a division of Western Cartridge, a skilled man can straighten a barrel in one minute.

The test for straightness is to sight through the gun barrel at a horizontal line some 15 feet distant. If the barrel is straight the horizontal line will be reflected on the sides of the gleaming



A high degree of skill is required for straightening crooked barrels

interior of the barrel as two straight lines converging to a point somewhat in the way the two rails of a track seems to join in the distance.

If the barrel is not straight the two lines will take all kinds of shapes and the operator must determine what point of the barrel is curved, in which direction or directions, and apply just enough pressure to take out the kink. Vision of a high order and the greatest delicacy of touch are required for this exacting work.

PLASTICS FOR NAVY

Resistant to Flame And Shock

COMBINING the qualities of fire- plus shock-resistance and easy molding properties, a new plastics has been developed for the Navy. Intensive research begun in General Electric's plastics laboratory has produced a product that can withstand fire and its resultant toxic effects during battle action, as well as the concussions and vibrations of battleship broadsides.

The Navy's specifications called for a plastics that was relatively fire-resistant and non-toxic, and had good electrical properties, high impact strength, and easy moldability. The laboratory men learned that it was impossible to use any appreciable amount of organic filler in a laminated plastics or molding compound to fit these specifications, regardless of what kind of resins were used, without obtaining a material that gave off toxic gases fatal to human beings, depending on several factors including the size of the room and length of burning.

The chemists then turned to the use of inorganic filler-type of materials, such as asbestos and glass. At the end of the long research road they selected asbestos as the type of inorganic filler they wanted because it embodied all of the specifications—relative high flame-resistance, low toxicity, easy moldability, and shock resistance. The researchers then bound the asbestos fibers together with certain phenolic resins to make a series of plastics with various shock resistances that would do the required jobs.

FLICKERING FLUORESCENTS

Now a Part of the Past of Lighting

ELECTRICAL engineers have written finis to the flickering of fluorescents. Incandescent lamps, their normal service given, blink out abruptly. Fluorescents, after many hours of bright and steady service, yielded grudgingly to the debilities of old age and flickered annoyingly as they passed through their death throes.

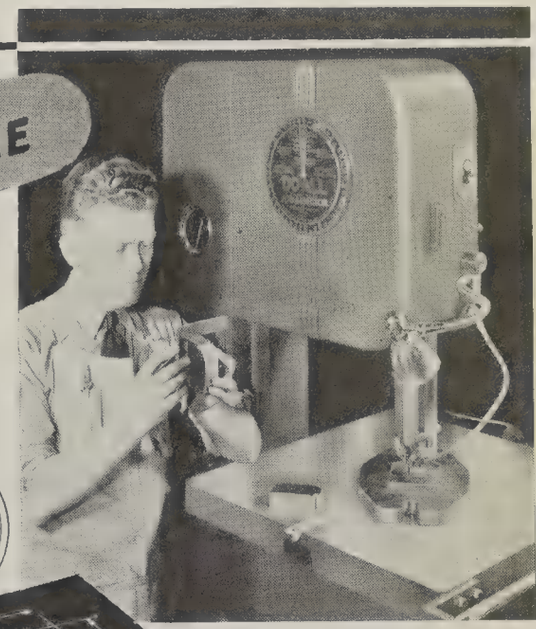
But no longer.

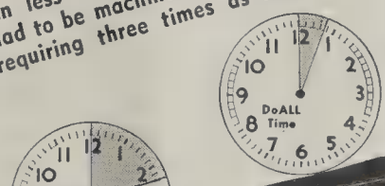
Engineers now have devised a tiny "electrical brain" which fits in a fluorescent lamp receptacle and automatically shuts off the current when the lamp has passed the stage of usefulness, according to information published in a recent issue of the *Westinghouse Engineer*.

All fluorescent lamps have a "starter," a small glow-discharge tube which provides a higher voltage initially to speed electrically-charged particles of gas into glowing action. By adding a resistor which heats when the lamp

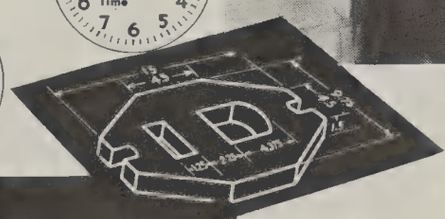
DoALL MAKES SHOE IN 1/3 TORCH AND SHAPER TIME

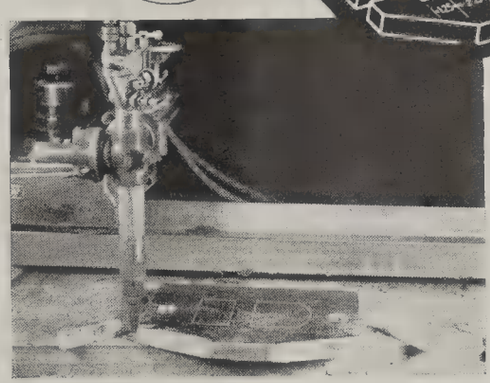
Forty-five minutes to cut this shoe from boiler plate—one easy operation and a square, clean finish.
An acetylene oxygen gas torch cut the shoe in less time, but the burnt edges then had to be machined—the two operations requiring three times as long.







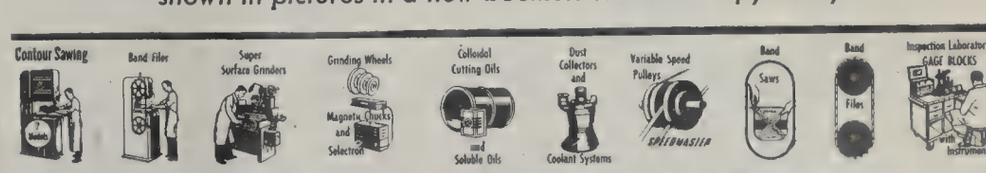




For rough shapes from mild steel, the torch offers a fast cutting method, but for machine finish precision work, use the DoALL.
Another thing, the torch will not cut non-ferrous metals, aluminum, brass, cast iron, bakelite, fibre products—the DoAll will. The torch is impracticable for tool steel shapes, which the DoAll handles easily.

Yes, DoALL cuts them all — today's most modern and rapid machining method. Does both internal and external cutting, following straight or contour lines accurately and without metal waste.

DoALL Advantages over 10 Basic Cutting Methods are shown in pictures in a new booklet. Write for copy today.



DoALL INDUSTRY'S NEW SET OF TOOLS

CONTINENTAL MACHINES, INC.
1916 S. Washington Avenue • Minneapolis 4, Minn.

Sales & Service Cincinnati, Dallas, Dayton, Erie, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, New York, Orlando, Philadelphia, San Francisco, Seattle, Syracuse, Toledo, Tulsa.

begins to function unevenly and with this heat activates a bimetal switch, operation of the tube is halted almost immediately. It ceases without the flickering which interferes with the lighting values of other nearby lamps and also causes damage to the associated equipment.

The new "starters" which contain the anti-flickering equipment are interchangeable with those in present fluorescent light receptacles, the magazine reports.

WHIRLING POWER

High-Speed Extractors Squeeze Dyes from Textiles

ALMOST three miles per minute is the rate of speed at which extractors are now used to squeeze dye liquors out of textile materials before final drying. These machines, made by the Fletcher Works under the trade name Whirlwind, are equipped with a hydraulic brake similar to that in an automobile, except that the braking is automatic and the momentum of the revolving basket builds up the pressure so that it actually stops itself.

Sheer fabrics can be handled safely in these extractors because the interior of the revolving basket is smooth. Both side plates and reinforcing bands are of stainless steel, selected because it withstands the corrosive attack of the various acids and other chemicals used in the dyeing processes and has sufficiently high tensile strength to permit high basket speeds with safety.—*Electromet Review.*

TWIST DRILLS

Made With Welded Chrome-Nickel Shank

SAVINGS in the manufacture of twist drills have been effected by the flash welding of high-speed steel stock to a chrome-nickel shank.

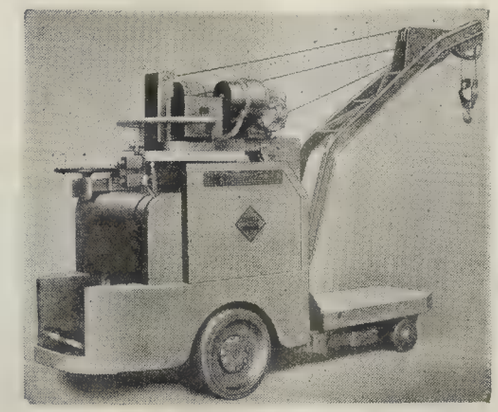
The photograph illustrates this process of welding an exceptionally large sized drill. The drill stock is welded to the shank before twisting—an excellent example of the strength of such a weld, in that it must be as strong as the parent metal to stand the twisting operation. After twisting, the drill is hardened and finished.

The water-cooled clamping dies for holding the stock and shank during the welding operations act as electrodes for the transmission of current to the parts being welded.

CRANE TRUCK

Serves as Load-Carrier And Tractor

A COMBINATION crane truck that can be used as a lift-truck, load carrier, crane, and tractor, loads itself either by picking up skid loads with the lift platform, or by lifting heavy parts



Four-use industrial crane truck

and placing them on the platform for transport. As a tractor it pulls trailer cars, which may be loaded by means of the crane. The crane may be made available for heavy lifting at points where there are no overhead cranes.

Manufactured by the Elwell Parker Electric Company, the model has a capacity of 6000 pounds on the platform, 2000 pounds on the hook at 42-inch radius, and 1000 pounds on the hook at 84-inch radius. It will travel at six miles per hour with no load and five miles per hour with full load under normal conditions. The platform is deeply flanged to insure rigidity and has three-point positive support that assures load stability.

FELT

Processes Revealed by Development Engineer

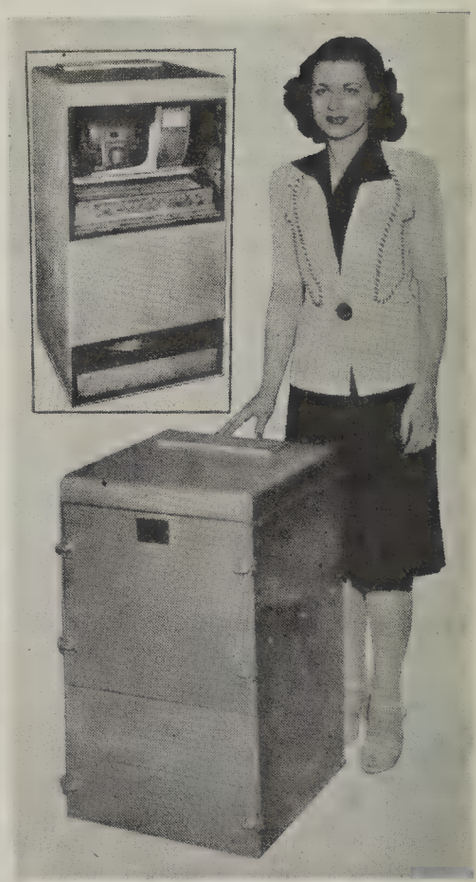
MODERN methods used in the manufacture of felt were revealed recently in a technical paper read before the American Society of Mechanical Engineers by W. H. Lehmberg, chief of engineering and development of the American Felt Company. Felt, one of the oldest and most widely used textile products, was originally made by crude methods but is today produced in the United States by machinery under close control, turning out standardized products and meeting a constantly widening market. Until recently, however, its technology has been a closely guarded secret.

Though felt is basically fabricated from wool, felt manufacture today embraces expert knowledge and use of more different kinds of fibers than any other branch of the textile industry, Mr. Lehmberg disclosed. Among other fibers blended with wool for special felt purposes are cotton, hair, jute, kapok, and ramie; also synthetics, such as rayon, vinyon, and aralac. A majority of felt products are all wool, however, and wool accounts for nearly 70 percent of the total fibers processed by the industry.

DUST COLLECTOR

Uses Compound Action In Portable Unit

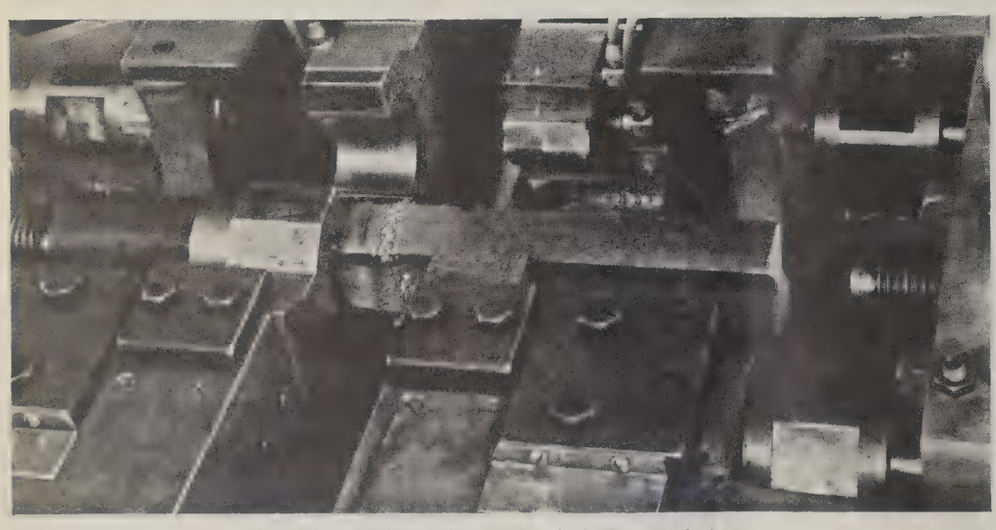
MANUFACTURED in four sizes, Dustex portable dust collector is designed to meet the need for an efficient and economical means of removing from the



Filters (inset) remove dusts that arise in many industrial operations

air dangerous and obnoxious dusts—lint, shavings, grindings, and so on—arising from industrial operations.

The principle underlying the unit is compound action on the air-borne dust, first by centrifugal separation from the air stream and, second, by impingement on the filter surface. The unit maintains constant static air suction of



Welding drill stock to shank before twisting

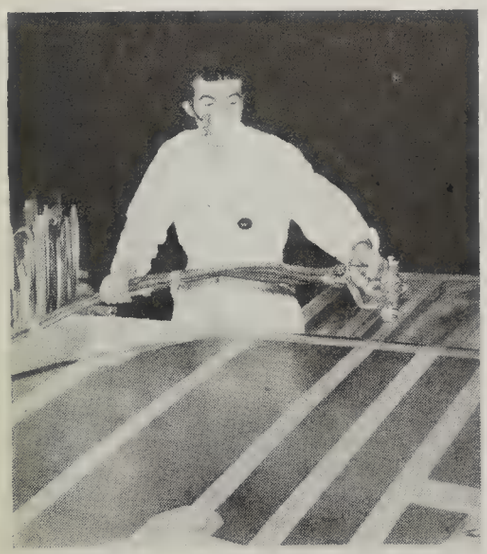
more than 4 inches at a velocity of over 5000 linear feet a minute. Units weigh from 75 to 200 pounds, and are 30 to 51 inches high.

The filter assembly consists of two corrugated layers of wire mesh covered with 60-mesh filter cloth. Filtered air is discharged through a muffler to deaden air noise.

HOT DOPE

Eliminates Need for Expensive Thinners

A NEW method of spraying aircraft "dopes" by heating them until thin enough to spray, rather than diluting



No thinner needed when dope is heated

them with costly thinners, has been perfected by the aviation finishes laboratories of The Sherwin Williams Company. Cutting the number of coats required from seven to three, the new method reduces doping time by more than half and has tremendously speeded up the production of expendable gliders for Allied airborne armies. It can also be used on light plywood planes and on control surfaces of transport and combat planes. Major post-war use, aside from plywood plane production, is expected to be in the application of tougher finishes to household appliances, automobiles, and so on.

CELLOPHANE

Keeps Grease In and Water Out of Metal Parts

GREASE-PROOF cellophane, which now goes into a special cellophane-cloth wrapping for ordnance parts, will find increasing use as a peace-time packaging material for machine parts and fittings to keep them from rusting while in transit or storage.

In addition to being impervious to grease, this cellophane is also water- and moisture-proof, and is neutral, having neither acid nor alkaline characteristics. Sylvania Industrial Corporation, which makes this material, reports that this last qualification calls for rigid production controls.

In packaging certain ordnance parts, a sheet of this cellophane is laminated with cloth, a special wax being used to seal the two together. The cellophane side of the wrap is then applied to the surface of the ordnance part, which has been coated with a thin film of oil. When the part has been completely wrapped the package is dipped in wax to seal it. The tough, durable cellophane-cloth wrapper is effective in keeping air, moisture, and water out and the grease in, and in that way prevents rusting.

GEAR PRODUCTION

Speeded by Cutting All Teeth Simultaneously

A NEW gear-cutting machine for the production of spur and helical gears, splines, and so on, has been announced by the Michigan Tool Company. The machine cuts all gear teeth simultaneously with radially fed form-tool blades having a shear-cutting action.

The new "Shear-Speed" is capable of rough and semi-finish cutting as many as 60 to 100 or more gears an hour, depending on the job.

The machine is exceptionally easy to operate and requires no particular skill. Gears are placed on the work holder, chucking being part of the automatic machine cycle. The operator has only to press a button to start the machine. When the machine has completed its cycle it returns to loading position automatically and releases the finished gear for removal and loading of another blank.

The cutting action of the machine is as follows: When the gear is automatically clamped, the head of the machine,



New Fluorescent "Flud-Lite" Magnifiers Increase Efficiency of Inspectors, Assemblers, Toolmakers and Machinists!

For use in every war-busy plant, this newly devised "Flud-Lite" Magnifier, increases eye-efficiency—reduces error—takes strain off the worker. The device, available in two models: bench-type (illustrated), and portable-type (without base and friction joint arms), does two vital jobs:

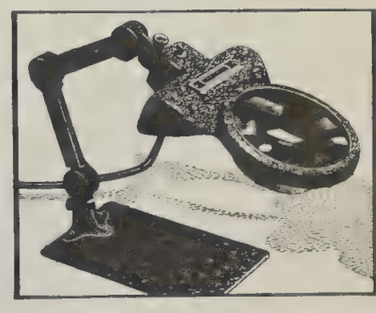
(1) Magnifies the work through a high-quality five-inch diameter lens. (For supermagnification, an attachment is available which doubles the power of the lens.)

(2) Floodlights the work with a built-in, glare-free, daylight fluorescent light.

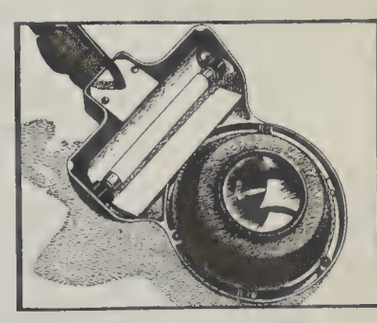
Frame and arms of "Flud-Lite" are die castings, ribbed for strength and efficiency. Durable black finish. Magnifier operates on AC current, 110-120 volts, 60 cycles. Precision built throughout, it's a help-on-the-job worth remembering.

Remember Wrigley's Spearmint Chewing Gum, too. Our guarantee of the product has always been uniform highest quality. That guarantee still holds, even though that familiar wrapper is now empty, because we have ceased manufacture of Wrigley's Spearmint Gum. And we will resume production only when we *know* we can make it up to Wrigley Spearmint standards.

You can get complete information from Stanley Electric Tool Division, The Stanley Works, New Britain, Connecticut

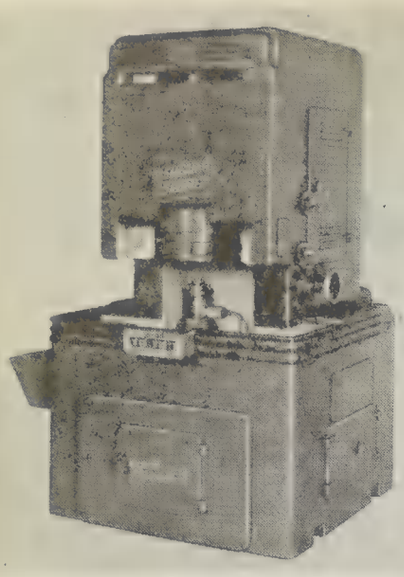


Bench type "Flud-Lite" Magnifier, with adjustable friction arm joints.



Bottom view, showing built-in fluorescent daylight lamp.

Z-63



Above: Gear cutting machine with cutter head in loading position. Left: Interior of the cutter head, showing assembly of individual tool blades

containing the cutter head, automatically lowers into cutting position and automatically locks there. The work now reciprocates vertically. At the beginning of each up-stroke, all blades are advanced radially (fed into the work) an equal amount. On the return stroke, the blades are retracted slightly as on conventional gear-shapers to provide clearance for the tools. The amount that blades are fed into the work on each stroke is adjustable. Correct sizing of the work is also automatically controlled and adjustable.

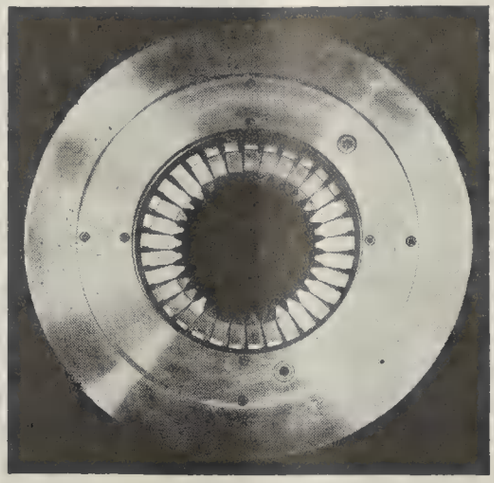
ABRASIVE WHEELS

Are Bonded With Synthetic Rubber

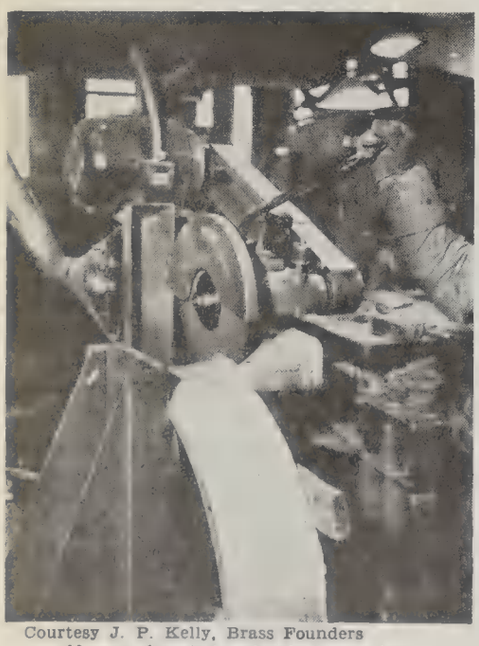
RECENT reports from abrasive wheel manufacturers say that a special-purpose synthetic rubber has been developed which permits the manufacture of fast-cutting, long-lasting abrasive wheels for the metal working trades.

A single wheel will do the work of 15 metal bandsaws in cutting gates and risers off non-ferrous castings. Multiply this one illustration by the thousands of other applications for abrasive wheels in industry to get an idea of what they mean to production.

Tests of abrasive wheels were conducted by West Company, Inc. To Hycar Chemical Company, makers of synthetic rubber, the results were reported as follows: "Manganese bronze castings were cut with a natural rubber-bonded wheel making 50 cuts for a total of 562½ square inches. A Hycar-bonded wheel on the same work made 99 cuts for a total of 1013¾ inches, practically doubling the output. Each wheel was 16 inches in diameter by ⅛-inch thick, operating at 16,000 surface feet per minute, 3800 revolutions per minute spindle speed."



The same company's tests on aluminum bronze castings were to take 10 cuts each with a natural rubber wheel and the special-purpose synthetic rubber wheel. The results reported were that the wheel bonded with Hycar cut 141 square inches and that the wear was .43 square inches per square inch of metal cut, in comparison with the natural rubber-bonded wheel which cut 112 square inches and showed a wear of .627 square inches per square inch cut.



Courtesy J. P. Kelly, Brass Founders

Hycar bonded wheels cut fast

ELECTRONIC COUNTER

Tallies Rates Exceeding Ten Cycles a Second

DESIGNED for industrial and laboratory uses, a new two-decade electronic counter is actuated by a closing contact, sine wave, or pulse input, as from a photo-cell, at rates up to 1000 cycles per second. Each decade divides by ten, giving a scaling factor of 100. The count for 0 to 99 appears on two banks of neon lamps.

A telephone-type relay is connected to the counter output and the contacts of this relay close once for each 100 input cycles. These contacts are connected to an output terminal. A conventional electro-mechanical counter may be connected to the output terminals to extend the count to as many places as desired.

One important application of the unit is in counting rates exceeding 10 cycles a second, which are generally too fast for conventional counters. Another is in installations where a conventional counter wears out prematurely from high-speed continuous operation or is unreliable. The new electronic counter, made by the Potter Instrument Company, makes it possible to increase the counting rate 100 times.

RUBBER CEMENT

Bonds Metal, Wood, and Plastics

NON-THERMOPLASTIC and water and aromatic oil-resistant, a new adhesive for bonding metals, wood, plastics, and ceramic material to themselves or to each other, is said by The B. F. Goodrich Company to provide superior bonding qualities in any of its applications. In some cases, it is claimed, this new rubber cement can be used in place of rivets or screws. Best results are gained by applying heat with pressure, although heating alone will give some degree of adhesion. The purpose of pressure is to obtain good surface contact. The bond strength varies with the materials being adhered.

The new adhesive, named Plastilock 500, has shown a shear strength of 3250 pounds per square inch. Tension strengths of 4000 pounds per square inch have been reached. Tests made after the bonding of wood and plastics to aluminum, which presents extremely difficult problems of adhesion to other materials, have resulted in the wood and plastics being torn because the strength of the bond was greater than that of these materials.

CELLULOSE PELLETS

Clean Engine Parts Quickly and Efficiently

A TIME-SAVING supplementary treatment has been developed for the successful chemical processes now in use for removing carbon from aircraft, automotive, and Diesel engine pistons and other parts. While prolonged soaking in specialized chemicals is normally required to remove tenacious deposits completely, a comparatively short-time bath is said to suffice if the new product, called Carboblast, is used. It removes residual carbon, oxides, and gums. Its pellets of ligno-cellulose are softer than any metal used in engine construction and cannot scratch or mar mirror-like surfaces. Because of this, and by reason of the fact that the pel-



Carbon removal from a piston, using cellulose pellets and compressed air

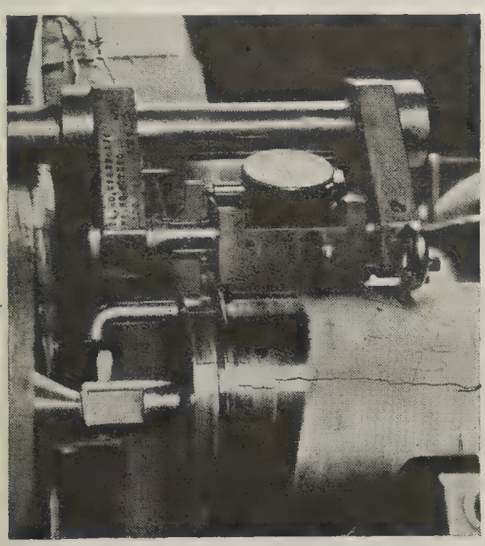
lets are essentially non-adherent as well as smooth and non-abrasive, there is no need to mask off bearings or bronze bushings, or to plug spark plug holes.

The narrowest recesses, such as piston-ring lands, cylinder fins, waffle underpiston structure, valve parts, and screw threads are readily penetrated and thoroughly cleaned by the pellets. Conventional sandblasting equipment is adaptable to Carboblasting.

GAGE FINGERS

Used in Grinding Aircraft Cylinders

USE OF carbide gage fingers has insured accurate gaging during grinding at a large aircraft engine plant, under conditions which would wear steel



Cemented carbide gage fingers make automatic gaging practical and materially increase machine production

fingers away so rapidly that the operator would be forced to continually reset his gage.

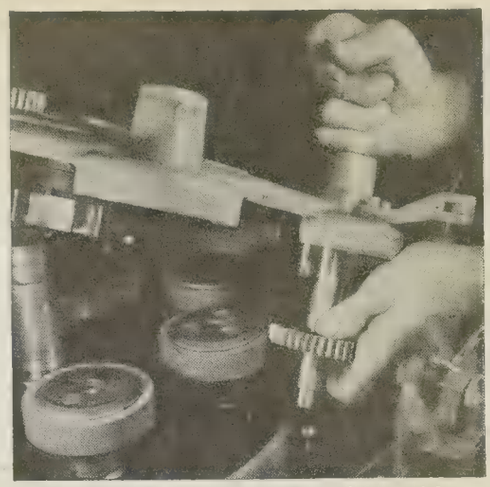
The job where these fingers are used consists of grinding the outside diameter of aircraft cylinder sleeves to extremely close tolerances. The gage fingers—made of Carboloy cemented carbide where they contact the rotating work—are so set that when the gage reads "O" they automatically shut off the machine feed, thereby saving an appreciable amount of time on long production runs.

Because no lubricant can be used on these gage fingers for obvious reasons, it is impractical to employ steel for this purpose. The Carboloy fingers, however, stand up under these conditions and are reported to have made this type of gaging fixture practical with a resultant material increase in production.

TRANSMISSION RINGS

Made of Long-Lived Vinyl Resin Derivative

ORIGINALLY developed to prevent gear breakage in the event of jamming, a unique type of power transmission involving rubber rings that mesh with metal gears on revolving turret machinery was in use in the eastern plant of a large radio manufacturer before rubber became scarce. In the course of a rubber conservation program, it was found that when the rings were made of compar, ■ vinyl resin derivative compounded by Resistoflex Corporation, their service life was increased several times. The tough, long-lived ring is molded of the same basic material used as the core of Resistoflex oil and gasoline-proof hose assemblies. The material is compounded to give the exact degree of flexibility, elasticity, and abrasion resistance required for each particular application.



Synthetic rubber rings, meshing with metal gears, provide positive transmission and give long service life

PLATE RECTIFIERS

Coated to Protect Against Corrosion

A PLATE construction in metal-plate rectifiers which allows complete coating protection against destructive atmospheres, now available, permits a new method of applying the protective coatings. Where the standard petal contact is sprayed with a protective coating, Center Contact is especially adapted to the application of a heavier and better coating to protect the rectifier from fungus-bearing, salt spray laden, or corrosive atmospheres.

The Center Contact construction, a

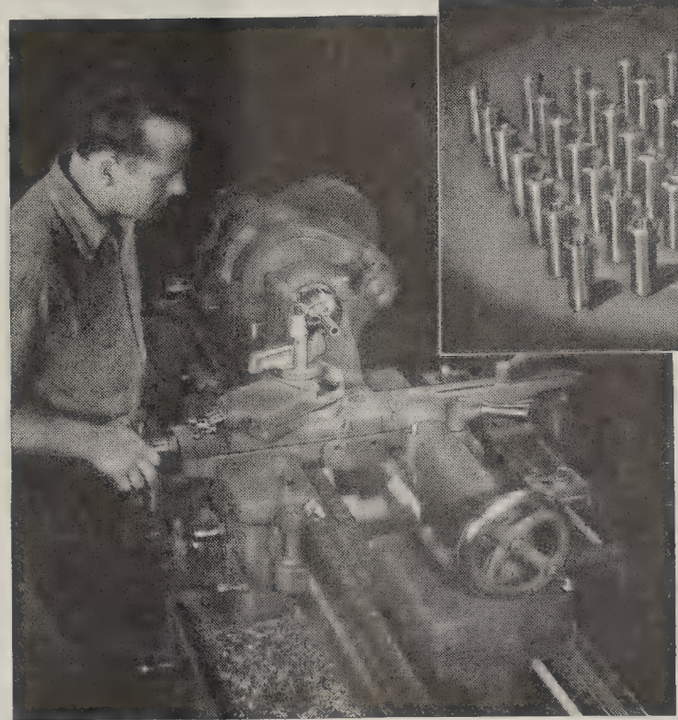
Versatility *for Precision Toolroom Work*



The ease with which South Bend Toolroom Lathes can be changed from one set-up to another for an almost unlimited variety of precision operations is one of the reasons for their popularity in the busy toolrooms of war-rushed essential industries.

Convenient, well placed controls; easy reading graduated dials; and smooth operation save time and reduce operator fatigue to a minimum. A wide range of spindle speeds permits machining various kinds of metals with maximum cutting tool efficiency. Threads and power feeds for all requirements are instantly available through a full quick change gear mechanism. A complete line of attachments and accessories simplifies tooling lathes for many special and unusual classes of toolroom work.

South Bend Toolroom Lathes and Engine Lathes are made in five sizes: 9", 10", 13", 14½", and 16" swing respectively. Precision Turret Lathes are available in two sizes: Series 900 with 9" swing and ½" collet capacity and Series 1000 with 10" swing and 1" collet capacity. Write today for catalog.



COLLETS

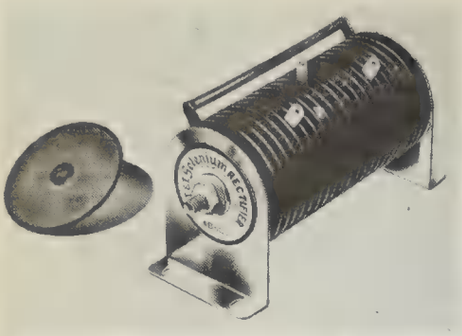
Collets for all sizes and types of South Bend Lathes are now being shipped directly from stock. All sizes from 1/16" to 1" diameter in steps of 1/64" are available.

Check your collet requirements today—for toolroom, maintenance, and production work—and order all you need. Often the time saved by having on hand the right size collet for a single rush job will more than compensate for the cost of a full set of these fine collets. Specify size and serial number of lathe.

BUY WAR BONDS—SAVE FOR LATHES

SOUTH BEND LATHE WORKS

453 E. Madison St. • *Lathe Builders For 38 Years* • South Bend 22, Ind.



Center contact in selenium rectifier plates permits better unit protection

product of Federal Telephone and Radio Corporation, is available in the same range of sizes and capacities as the standard petal-type contact. It retains the features of high voltage per plate, ability to withstand heavy temporary overloads, and operates at high efficiency over a wide range of capacities with no maintenance expense.

SCREENS

Made of Stainless Steel For Process Industries

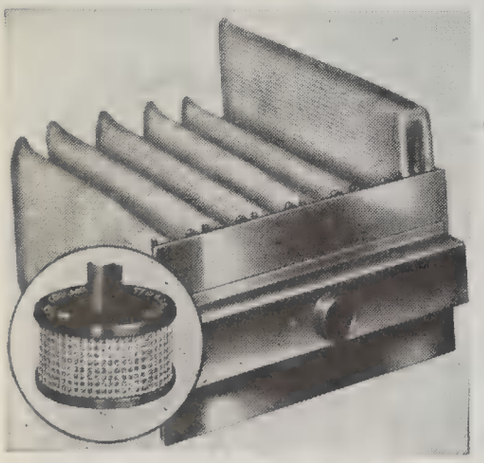
FOR USE with all types of process water, a new stainless-steel screen has proved satisfactory, according to the manufacturer, in installations in paper mills, textile mills, and other process industries. The face of the screen is a fine mesh stainless-steel wire fabric which is backed up by a heavy gage screen of about one inch square mesh. Behind this backing are the horizontal back struts of the frame itself, thereby providing maximum resistance to bellying and buckling of the fine strainer under water pressure.

The unit, made by the Rodney Hunt Machine Company, is light in weight and easily removed for quick cleaning. It is available in any dimension desired and can also be supplied with specially designed frames and quick acting hoisting apparatus for removing frames for cleaning.

OIL STRAINERS

Easily Installed On Machine Tools

USED on machine tools for straining cutting oils and coolants and for other installations using flood oiling, a new Metex strainer has the following features: No strainer housing is required. The strainer is installed in the tank and the oil or coolant is piped direct from strainer to pump. Strainer units are a unique combination of wire and cotton, inter-knitted into a mesh by machines especially developed and designed for this purpose. This makes a strong, non-collapsible strainer unit. All have a large strainage area. Exceptional capacity to hold dirt, grit, and chips can be provided in the larger units where there is sufficient space for installation. These strainers are made by the George Butler Company.



No housing required for this strainer

GOGGLES

Kept Free of Moisture By Wearer's Breath

NORMAL breathing has been harnessed to make a natural ventilating "pump" for a new goggle which cannot cloud up or fog, regardless of how much the wearer perspires. Fitted with a bulbous nosepiece, the new fog-free goggle is powered by ordinary lung action. Normal breathing sweeps a complete change of fresh air in front of the wearer's eyes many times a minute. This action removes moisture from within the goggle before there is enough of it to condense as fog on the plastics goggle lens.



Air is drawn through intake ports of the goggle as the wearer inhales

The new goggle, designed by Polaroid Corporation engineers, has flow channels built into the goggle frame to guide air circulation efficiently.

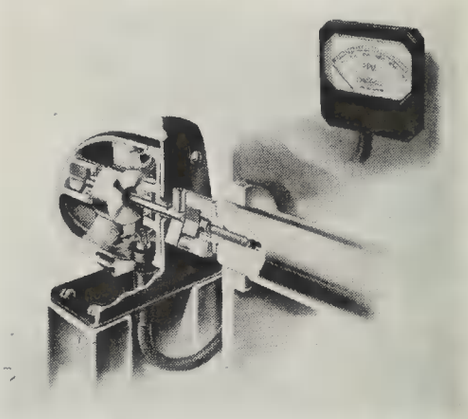
Inhalation draws air through the intake ports of the goggle. The air then sweeps across the inside of the lens, and passes through an inlet valve into the nose. Exhalation closes the inlet valve and opens the outlet valve in the base of the protruding nosepiece.

MACHINE SPEEDS

Determined with New Electric Indicator

STURDY and accurate, a new electric speed indicator makes it possible to determine and to set proper operating speeds in a broad new field of applications.

The Reliance electric speed indicator, which gives accurate readings of speeds from 100 to 5000 revolutions per minute, consists of two units. The pick-up unit, a miniature six-pole alternator with a permanent magnet rotor, is mounted on the shaft whose speed is to be measured. The indicator, a permanent magnet, moving-coil type, meters the pick-up output on a 3¾ inch scale which covers 95 degrees of arc. The resistance of the indicator has been made sufficiently high so that the size or lengths of the leads connecting the units will have no effect on accuracy, and the indicator may be located at any distance from the pick-up unit. The indicator is not affected by other magnetic material, and there is no loss of accuracy due to length of service.



Electrical speed-indicating scale may be located remotely from the machine

ALLIGATOR-JAWED RIVETER

Exerts Powerful Bite, Acts as Own Backer-Up

IN MANY modern aircraft plants, alligator-jawed compressed-air riveters are exerting powerful bites in doing their jobs of fastening two metal parts together. Whether the job calls for ⅛-inch steel, 5/32-inch Duralumin, or 3/16-inch aluminum rivets, the 9½ pound hand riveter completely and firmly heads each rivet for safe flying.

Compressed air, of course, is a vital form of power in most every war plant, whether aircraft, shipping, or ordnance, but among the more common applications of riveting, drilling, brushing, and reaming, none is more dramatic and none answers a more difficult mass pro-



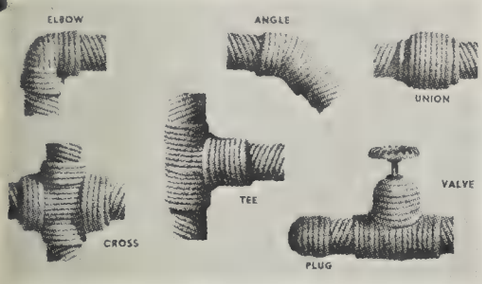
Compressed air squeeze riveter at work in speedy aircraft fabrication

duction problem than the compressed air squeeze riveter. This modern development of air-powered tools acts as its own backer-up and riveter.

CORK-FILLED TAPE

Stops Drip From Cold Water Pipes

A CORK-FILLED, pliable tape is being manufactured for installation on water pipes to stop drip from condensation. Bearing the trade name Nodrip, the tape is said to be quickly and easily applicable without the need of



Tape that stops drip may be applied regardless of shape of pipe joints

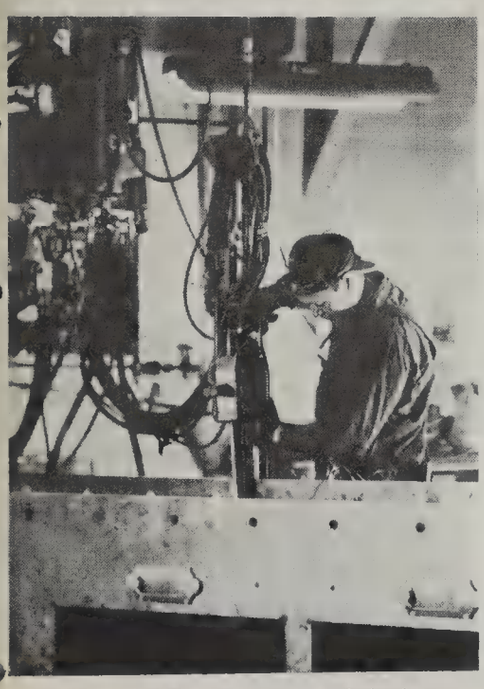
tools or special skill. Forming a sealed jacket around the pipe, it requires no maintenance and lasts a long time. The tape is normally brown in color but can be painted.

PORTABLE WELDING GUN

Solves Problems in Stove Assembly

HELPING to overcome manpower shortages and speeding the delivery of cooking ranges to the Army, Navy, and United States Maritime Commission is the production record of a heavy-duty portable spot-welding gun installation at the Washington Stove Works. The installation was developed and produced by the Progressive Welder Company.

These range assemblies were formerly riveted, the process requiring 1½ hours or longer. As the body of a large



A spot-welding gun, suspended above the work, solves production problems

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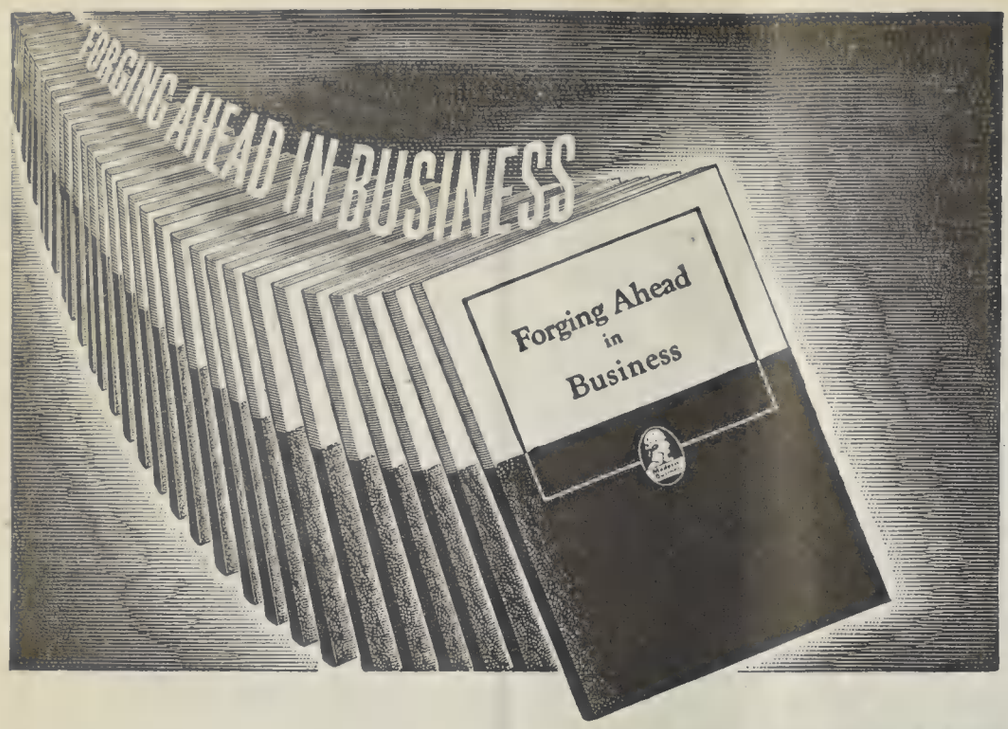
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range is too heavy to be spot-welded on conventional stationary equipment, a spot-welding gun—suspended by cables from above and counter-balanced so that it can be moved in any direction—is used. This permits the electrodes to be brought to bear readily on any desired point of the range body, cutting production time for this assembly operation to 15 minutes or less. Possibilities of either burning the metal or underwelding are eliminated by automatic time and heat controls.

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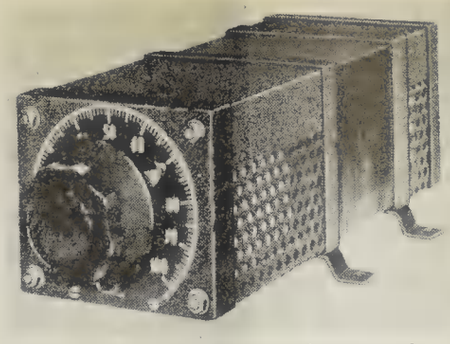
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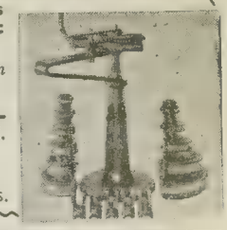
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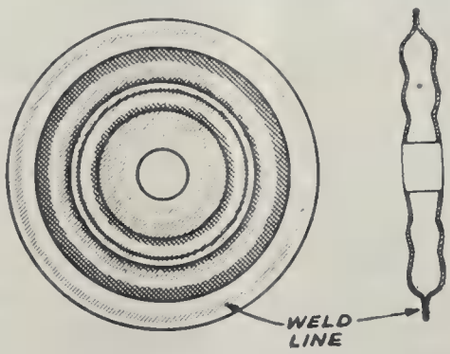
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squeezer. The bearings are simply put in where the orange used to go, then a spray of oil is sent over them as they whirl around in the container. The bearings are taken out by tweezers, never handled by human hands. The cleaning fluid drains from the spout.

PRESSURE GAGE DIAPHRAGMS

Can be Successfully Welded, Eliminating Crimping

DIAPHRAGMS for sensitive pressure gages are now being produced by seam welding instead of the old method of crimping and soldering the edges. Formerly made of beryllium-copper, or phosphor-bronze, these diaphragms are now manufactured of stainless steel



A pressure gage diaphragm, showing welded seam that eliminates crimping

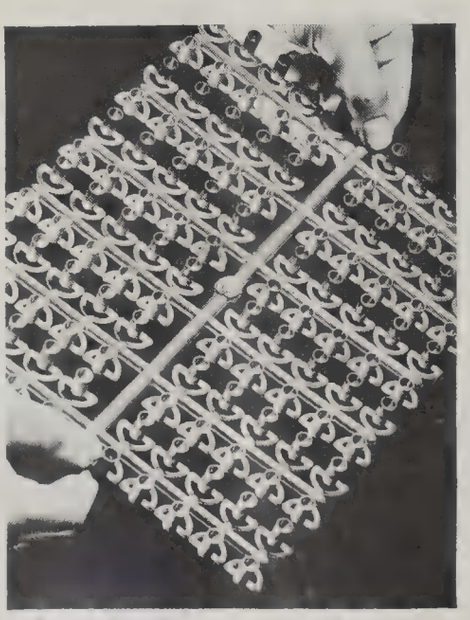
and Monel, ranging from 0.006 to 0.008 inch in thickness.

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for checking readings. Since it is designed to be used only for checking purposes, it retains its original accuracy for a long period of time. When checking, the master diamond penetrator replaces the regular penetrator in the machine.

The same is true of the two master test blocks. Held to extremely close limits, they are used only in connection with the master diamond. The resulting combination furnishes an accurate check of the machine, either as a periodical measure or whenever readings may be in doubt. The Clark Master Diamond Checking Set is furnished ready for use in a fitted case.

PICKING STICKS

Have Long Life When Made of Bonded Wood

THE Australian textile industry is using resin film with great success in bonding woods for the picking sticks which throw the shuttle back and forth across the loom. Acute shortages of hickory led to the development of the new type picking stick. The service life of these bonded sticks is reported to be from 1500 to 2000 continuous operating hours, contrasting with other wood sticks which gave an average loom life of 25 hours. No splitting or mechanical failure occurred during the periods of normal operation, and the laminated sticks are discarded only when completely worn out.

After Pearl Harbor, Australian supplies of hickory picking sticks from this country were cut off. Sticks made from woods which were brittle or of crooked grain broke after short periods and the stress concentrations in badly shaped or roughly finished sticks hastened failure. It was discovered that, in the manufacture of laminated and compressed woods bonded with resin, any desired mechanical properties could be obtained merely by increasing or reducing the amount of resin impregnation.

The resin film now being used is a special phenol-formaldehyde type manufactured by the Resinous Products and Chemical Company. In the bonding operation, wood veneers are permanently fused together with the film in a hydraulic press under heat and pressure, yielding plywood which withstands boiling water, mold, heat, and freezing.

BAILER'S GLOVE

Designed to Protect Wire Strappers' Hands

THE GREATLY increased use of wire and steel tape for preparing shipments has made imperative a special type of hand protection for the operator of the "strapping machines." To meet this



Proof against wire and steel tape

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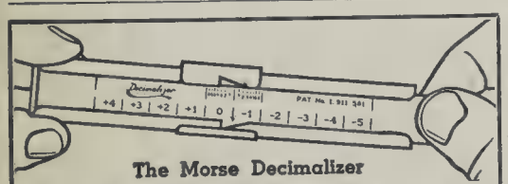
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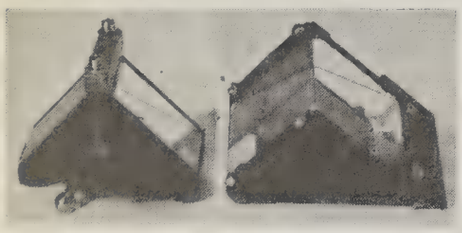
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Telescoptics

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THE following notes relate to the two-part article on making objective lenses by the test-plate method, by Patrick A. Driscoll of Rochester, in the March and April numbers.

In "A.T.M." page 71, the middle paragraph suggests a principle known as the "unit focus" principle: all the pertinent design data—focal length, diameters, thicknesses, radii of curves—in this instance of an eyepiece, may be divided or multiplied by any amount chosen (of course with due consideration to practical limitations), provided this remains throughout the same amount. These changes do not, of course, change the focal *ratio*.

When this fact was called to Driscoll's attention as a possibility for use in connection with his lens specifications he replied: "Now that you dig up one of the deep 'secrets' of our optical wizards that the amateur is not supposed to be let in on, I may as well let the cat out of the bag. An achromatic doublet can very easily be reduced in this way. For example, a 6″ can be reduced to a 3″, simply by dividing everything—except, of course, index and dispersion—by 2. It is as easy as that. I didn't put it in my story because if I'm makin' a lens, then by jeepers I'm makin' a big one—which by this method is as easy as a little one—and then the finished article is a man-sized hunk of apparatus. But I suppose the monetary outlay for large blanks is a consideration. If you reduce my 5¼″ to, say, 3″ or so, you reduce the aberrations; also the range of the figure of each surface is not quite so critical and the performance will be slightly better; but—a warning—do not *increase* the diameter unless willing to accept an increase of these same characteristics. At least, if you risk this, the surfaces must be very exact, else performance will suffer."

In weighing the matter of size, "A.T.M.A.", page 192, bottom paragraph, should not be overlooked.

This unit focus opportunity confers an added degree of freedom on the test-plating procedure, and if now we amateurs can between us collect and pool a variety of specifications for tried and good objective lenses, this method will enjoy still more freedom. Incidentally, there also is nothing about this method which forbids anyone from designing his own objective, just as in the other method, and in the most rigorous way if desired; yet it does make available to those who aren't too happy when tussling with design (as a few aren't, according to your scribe's mail) a chance to make and enjoy their own refractors. By this method the amateur's fear of the convex surface also is resolved, and it enjoys other advantages.

Specifications for two types of cemented and two of uncemented objectives, given on the unit focus basis, appear on page 29 of the newly published book, "Telescopes and Accessories," by Dimitroff and Baker. (This is the book which was given an advance review on page 466 of the 1941 printing of "A.T.M." — it has finally been published.)

Driscoll's specifications call for objectives of rather short focus (large focal ratio); that is *f*/12, and *f*/13. Ellison calls for *f*/15 or *f*/16 and so do some others. Questioned about this, Driscoll answered: "The 5¼″ was computed for me as an ideal astronomical glass that would utilize easy *c* and *f* and not require too precise adherence to stated tolerances." Dr. D. Everett Taylor has made one and has reported it good, in the April number.



Patrick A. Driscoll

Driscoll's method of calipering the edge of the lens elements during preliminary work—tipped micrometer anvils and stop block—happily complements Ellison's always questionable if not inadequate method in "A.T.M." (pages 115, 117), for it is otherwise almost impossible to caliper a tapered surface twice alike to close tolerance. In "A.T.M." (page 250) Haviland describes an edge gage involving three steel balls and a dial gage (a similar rig is used at the Bureau of Standards and reads to 0.0002″ as the lens is rotated in it, according to Ferson), and in Scientific American, February, 1940, D. Everett Taylor also described a very beautiful combined edge thickness gage and spherometer. Both of these contribute in large measure to precise work.

Any who give Driscoll's procedure or program a workout are urged to report all their experiences, impressions, opinions, and findings—its best, its worst. It is hoped that this flatless, test-plating method will result in a larger proportion of refractors being made.

THE REFLECTOR is a splendid telescope but in recent years more and more amateurs have quietly expressed their conviction, gradually arrived at, that on balance the refractor is even more satisfactory, giving steadier, better resolved, sharper, even if less brightly illuminated, images that stand higher magnification, especially for planetary and lunar observation. Here are some recent comments from amateurs who seem happy about their new refractors.

"I still use my 10″ Cassegrainian, but the second-hand 5½″ Brashear refractor I just bought has so much better definition and resolving power that there is little point in using the Cassegrainian. Almost any night I can use the quarter-inch eyepiece."

Another: "I have just finished a 2¾″ objective lens, my first, and from here on I am on refractors. This telescope defines perfectly."

A third: "Refractors at times throw theoretical resolving power out the window."

Of course, these are warm statements reflecting new enthusiasms, and they may be subject to some discount. The reflector is an excellent telescope but the notion that there is something inferior about the refractor is all wrong. Maybe 'twas a rationalization, because making one called for a lathe and a flat. Pat Driscoll's program now lops off the flat.

CERIUM OXIDE is now strongly competing with rouge in the optical industry. The following notes on that new polishing abrasive are by Frank Allen Lucy, 3427 W. Penn St., Philadelphia, Pa., who has contributed to this department before (July, 1943—notes and equations on Gee's method of figuring Cassegrainian secondaries by the test-plate method):

"People in increasing number have been recommending ceria (ceric oxide) in place of rouge for optical polishing. On the credit side, it is said to be cleaner and faster than rouge, less likely to cause sleeks, turned edges, or tarnishing on aging. On the debit side, it is said to cut so fast that it makes delicate figuring difficult, and to give a dull surface at first, which brightens only on long polishing; so that some think it unsuitable for final figuring, in which the periods are necessarily short.

"The writer's observations on the use of ceria may interest other optical workers. Ceria, being practically white, is certainly cleaner than rouge. Minimizing turned edge seems a matter more of technique than of agent. The commercial sample in our laboratory contains particles ranging widely in size. Probably, if used as received, it would give a dull surface at first, until the coarser particles were well driven into the pitch of the lap, after which

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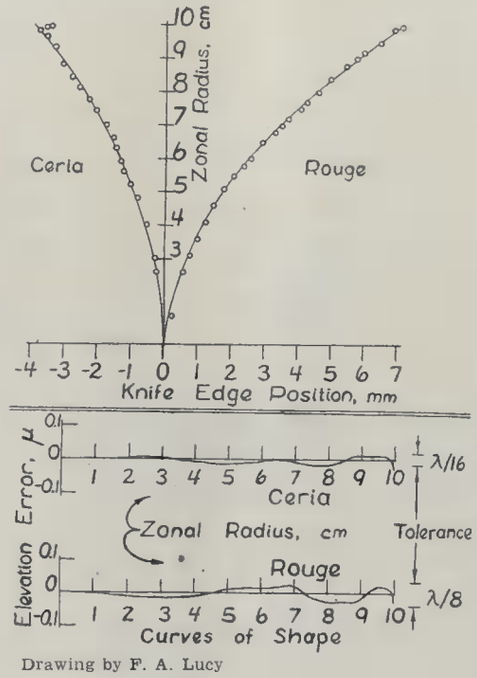
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the surface would brighten. However, when shaken with water and a wetting agent (Duponol D happened to be the readiest to hand), this ceria was readily dispersed and levigated. The levigated material gives a brilliant polish on any glass from dense barium crown to Pyrex, and works, in my estimation, about twice as fast as rouge of similar scratchiness.

"The scratches here referred to are those necessary ones which remove material in polishing, the scratches which fuzz the edges of a knife-edge shadow. (A. W. Everest, on page 22, 'A.T.M.A.,' says, 'Also decide right here what you are going to *call* the shadow; probably the point where none of the remaining spiderwebs of light crosses the pin.' These spiderwebs are diffraction patterns of scratches, scratches usually too small to be seen by direct examination but nevertheless capable of diffracting light.)



Drawing by F. A. Lucy

Cerium oxide versus optical rouge

"Polishing speed was judged by the length of spells necessary to produce a given rate of approach to an aspherical figure, starting from a sphere. Thus, if 40 minutes with rouge produced 5 percent of the total correction, 20 minutes with ceria was found adequate, under the same conditions, to produce another 5 percent. Other workers have stated that ceria is faster than rouge by factors ranging from 1.3 to 4 times. Particle size and possibly shape, hardness of pitch, polishing speed, and pressure, proportion of water, rate of feed, and so on, all affect the rate at which glass is removed, making a truly scientific evaluation of this factor difficult. Further, a set of conditions which gives the best results with a given rouge sample is not the best set for any other rouge sample, and is most unlikely to be best for a given ceria sample. The consensus is, however, that properly handled ceria is decidedly faster than properly handled rouge.

"Some hold that ceria is good for coarse work but not for fine. To this, the writer cannot subscribe. For example, Dévé states, 'It is less recommended for precision polishing because, precisely on account of its "bite," it is less suitable for removing infinitely small layers of material.'

"Actually, the precision attainable in figuring with ceria seems to be at least equal to that attainable with rouge. The diagram shows the errors of two mirrors, one polished entirely with rouge, the other started with rouge but taken most of the way with ceria and finished with twice-levigated ceria. The curves of shape were determined by a method practically identical with that described by F. B. Wright in 'A.T.M.' (chapter on accuracy in parabolization). The knife-edge readings were made by Everest's shadow crest method, and the integration was done mechanically instead of numerically.

("Incidentally, these curves highlight the necessity of using a micrometer screw to move the knife-edge when a deep curve is to be measured. Although none of the discrepancies shown in the diagram would be detectable, let alone measurable, by the pencil mark and ruler technique, the mirrors are not actually exceptionally good, being only comfortably within the tolerances required for their intended applications.)

"In the upper graphs, observed knife-edge displacements (circles) are compared with the ideal values (curves). The lower graphs show the disparity between the observed and ideal cross-sections along radii from the center outward. The wavelength (λ) in terms of which the tolerance is expressed is the wavelength of maximum visibility.

"It will be seen that the ceria-polished mirror was brought much closer to perfection than the rouge-polished one. It would have been possible to have brought either closer still, but there is no sense in further working an optical surface which is within the assigned (Wright) tolerance."

CERIUM OXIDE may be had from the Universal Shellac and Supply Co., 401 Broadway, New York 13, N. Y., which, by the way, is not the supplier mentioned, in part adversely, by Lucy and, anyway, ceria has greatly improved.

Commenting on this new polishing abrasive, the Ferson Optical Co., Biloxi, Miss., which has been using it says: "It has a heavy drag in polishing, polishes faster than most rouges, seems to have less tendency to scratch, in our experience has more tendency to turn edges but not much more, and should be used with a hard lap."

Barnesite, a somewhat expensive polishing abrasive from the same source, is held to be even better than cerium oxide by many professionals. (Incidentally, while on abrasives, the new "garnet fines" developed for wartime optical uses, and now being obtained from the same source, are rapidly moving in on fine emeries as a finished abrasive for grinding.)

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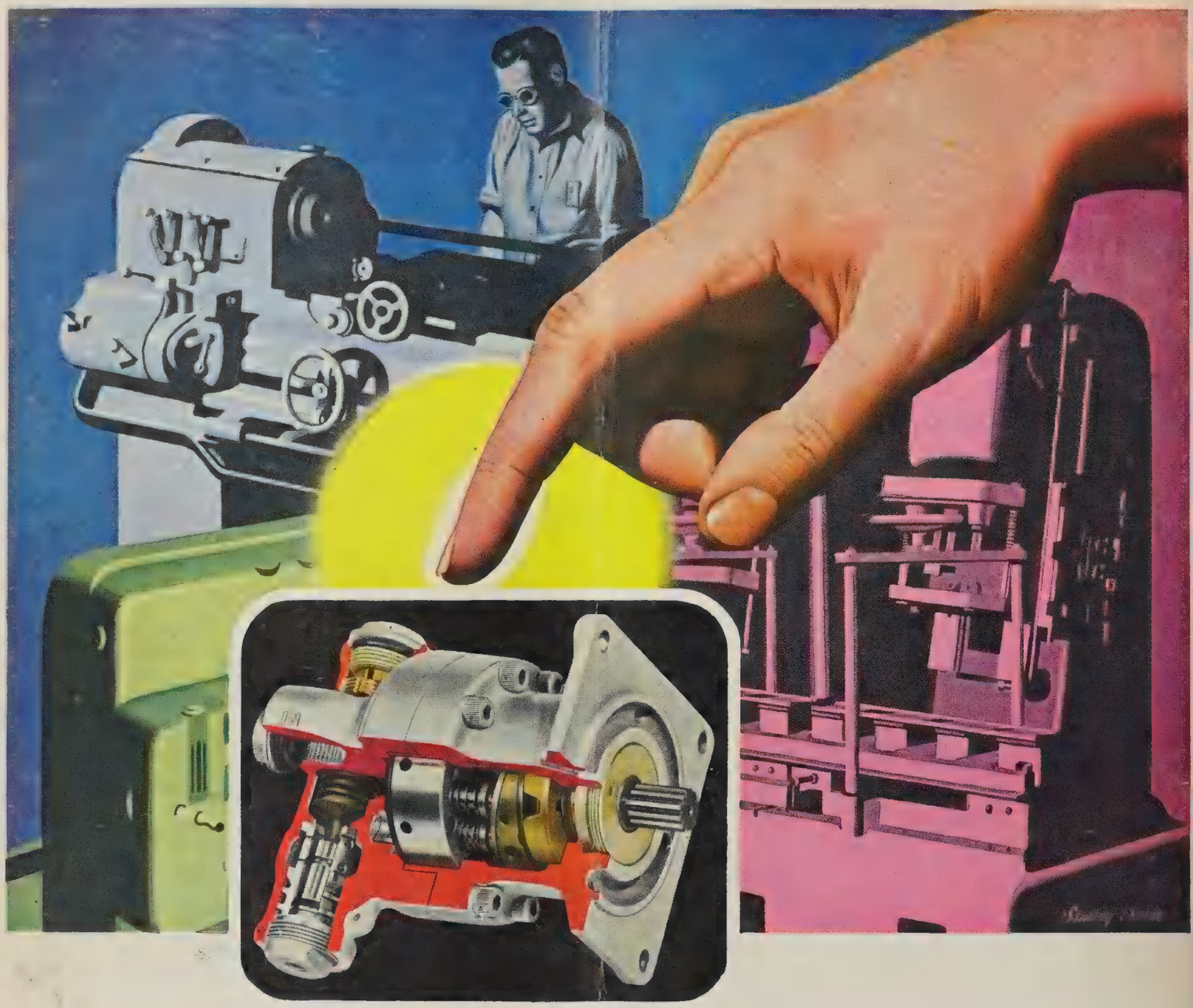
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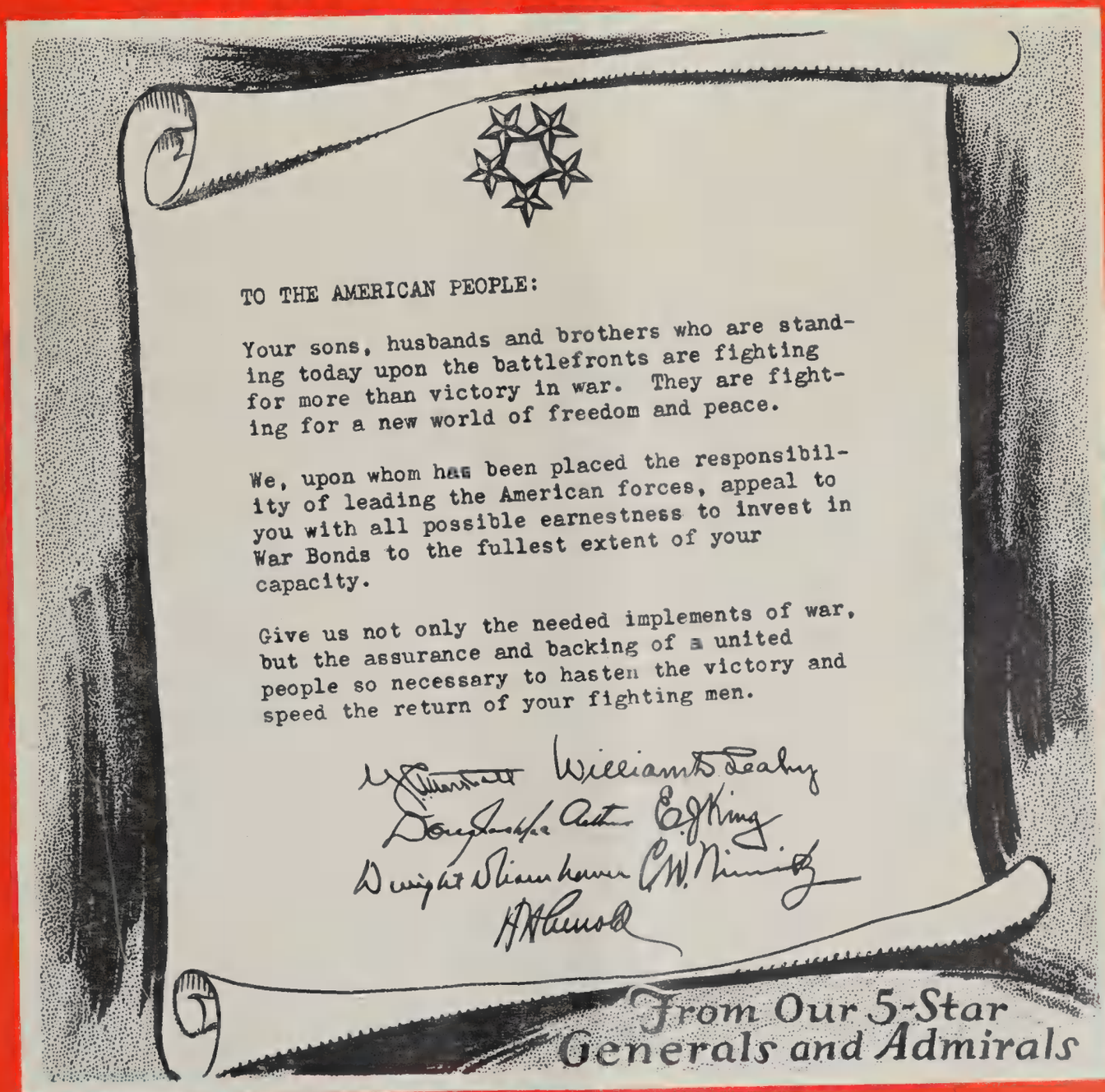
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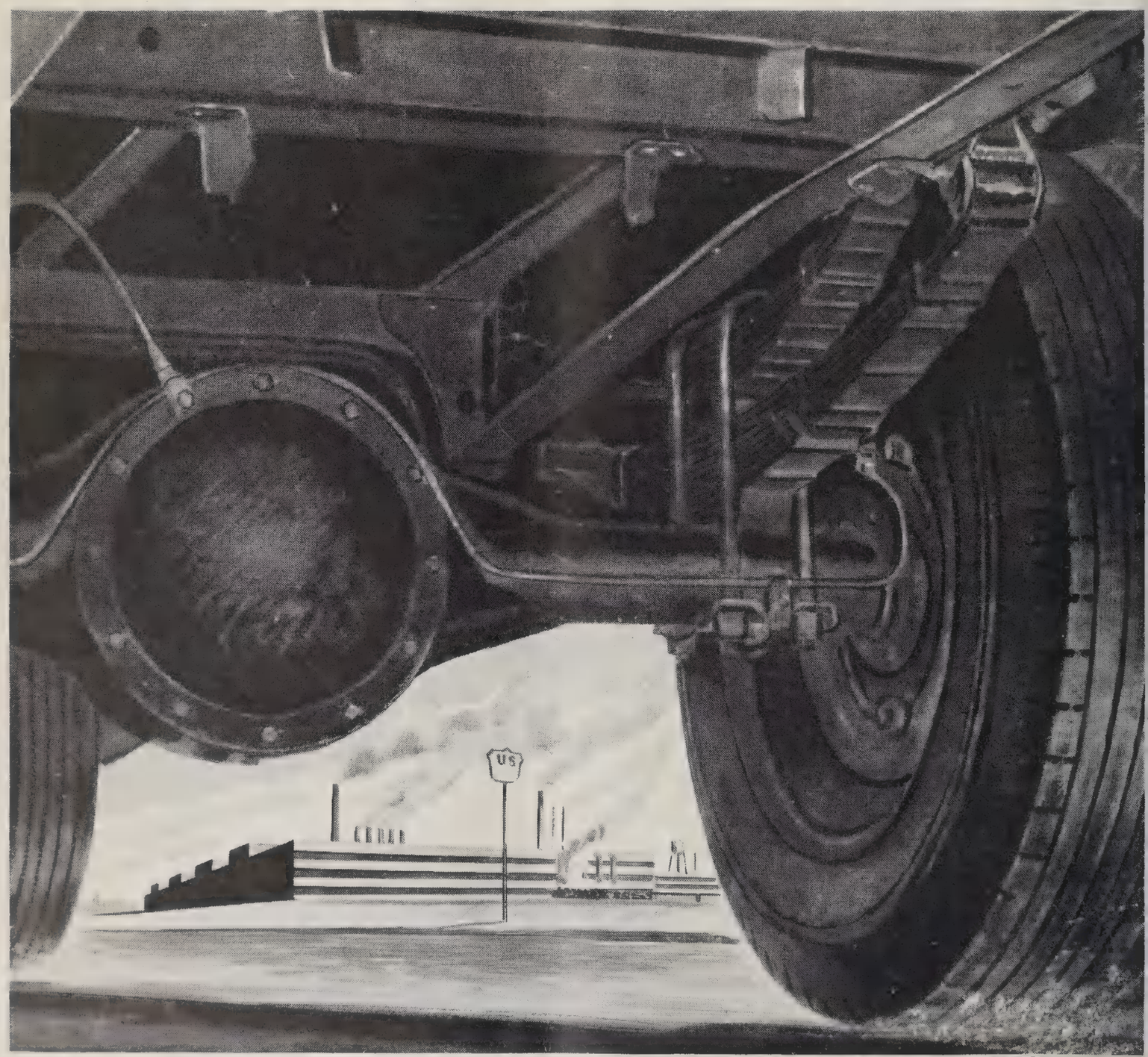
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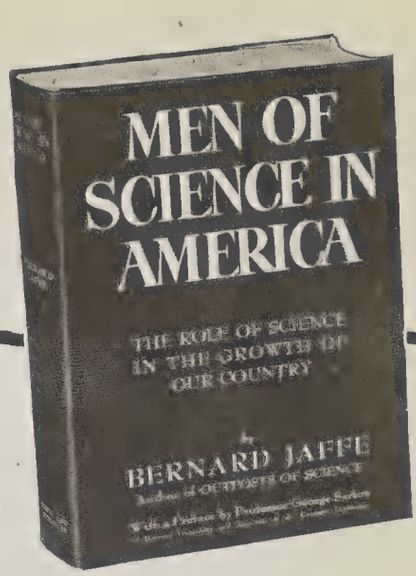
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Previews of the Industrial Horizon

By A. P. Peck

LOWER PLANE COSTS

ONLY a casual stroll along a present-day airplane assembly line is needed to reach the realization that much of the work done is accomplished by hand and that the multitude of parts that go into a single plane must boost the cost tremendously. True enough, aircraft plants of the United States are turning planes out by the thousands, but at a price per unit that would hold little hope for those who foresee the sky of the future filled with private planes bent on pleasure and business alike.

It is one of the axioms of mass production that simplification is necessary to reduce cost and increase the number of any article to be made. However, insistent demands for the planes of war have left little time for engineers to gain the necessary know-how of simplification; they have had to turn out planes regardless of cost in dollars, man-hours, and materials. Even with this immediate urge, they have not entirely disregarded the problems of the future. Probably they do not dream of an airplane in every garage or a landing field in every backyard, but they do know that there is going to be a zooming demand for private planes post-war and that this demand can be met only by planes that can be bought by other than millionaires.

Thus, engineers in at least one large aircraft plant have been turning some of their attention to production processes that will radically reduce costs. As examples of progress made, a stabilizer that formerly involved fabrication of 42 different parts is now made with only ten, and a wing was redesigned so that 21 parts take the place of the 134 formerly required. On this basis it is estimated that airframe costs, once ranging from three to ten dollars or more a pound, can be reduced to less than one dollar a pound, exclusive of engine. Projecting this trend a bit farther, Republic engineers look forward conservatively to comfortable, roomy private planes that will sell, post-war, for about the cost of a medium priced pre-war automobile.

While on this subject of airplane costs, it is interesting to note that recognition is being taken at last of the importance of standardization of plane parts from the servicing angle. So long as planes have individualistic electrical systems, lubrication fittings, fuel connections, propellers, spark plugs, and so on, the servicing problem for private planes and commercial airliners alike will be complicated and costly. But when standardization comes into the picture and makes it possible to service all planes quickly and to replace parts from an airport stockroom that does not have to carry a multitude of parts for which there is a call only once a year, then a long step will have been taken toward making aerial transportation available to the masses.

HEAT BY WIRE

MANY a head is getting gray—or bald—worrying about what will be done post-war with the huge hydroelectric plants that are now supplying needed power for war industries. Out in Oregon, the Bonneville project is a case in point. When war needs end, Bonneville's excess power will have to be absorbed if the whole project is not to become a complete white elephant. To avoid such a disastrous occurrence, plans are well underway to promote electric heating of homes, thus soaking up the excess juice and offering to householders a heating means that promises freedom from smoke and soot, freedom from drafts, and freedom from widely varying winter-time temperatures indoors. Most promising of the many schemes so far considered is the use of more or less conventional radiant heaters recessed into the wall and thermostatically controlled.

But what to do with the power during warm weather? The capacity of the generating plant must be utilized over the entire year if economy is to be realized. Air conditioning in summer, heavy refrigeration that would include quick-freezing equipment for homes and for communities, and electrically powered sprinkler irrigation systems are all part of the picture. Here is one of those cases where, once the initial cost to the householder is written off, the more current he uses the more he will benefit.

TELEVISION PROGRESS

BETTER and better television is seen on the horizon, as exemplified by the large-screen receiver detailed on page 362 of this issue. But, as Scientific American has always held, there is more to practical television, as far as the average man is concerned, than technical perfection. Other factors that must be considered include programming and the question of who will pay the bill. All of the problems are neatly wrapped up in capsule form, with many implications between the lines, by Dr. C. B. Jolliffe, head of RCA Laboratories, who recently said: "Engineers should not be satisfied that their television job is done until they have made it possible to project in the home pictures of adequate size in color [We will be satisfied with *good* black-and-white. *Ed.*] and also for anyone to attend—by television—all major happenings wherever they occur, in the United States or in any other part of the world. These objectives may be accomplished in a few years, or many years may be required."

PHILOSOPHY OF PLENTY

THOSE who would quarrel with the peculiarly American tendency to discard material objects before they have worn out completely and to replace them with other and more improved devices can take a lesson from a recent statement by Alfred P. Sloan, Jr., chairman of General Motors. In these words Mr. Sloan aptly sums up the philosophy of American production and consumption that has made it possible for this country to progress so rapidly, in peace and in war: "Some have the idea that the reason we in this country discard things so readily is because we have so much. The facts are exactly opposite—the reason we have so much is simply because we discard things so readily. We replace the old in return for something that will serve us better."

FOR FUTURE REFERENCE

SOME success has been achieved with solid paints, using no solvent, that are applied in a molten state under steam and air pressure. . . Assistant Secretary of Commerce Burden sees 6300 civilian airports on the horizon, with 400,000 airplanes in use in the United States within ten years after war end. . . At least one automotive engineer crys down the extensive use of aluminum in automobiles as a substitute for steel until the price, now 15 cents a pound, drops to 4½ cents a pound. . . Radio sets and kitchen ranges will probably lead the parade of appliances that will reach the home after the war. . . The steel industry looks with bright eye on the distant horizon, banking on conversion jobs, planned public works, and new bridge construction to keep it going full blast; apparently it has no fear of war-developed materials that might substitute for steel. . . Fluorescent lighting is scheduled for a boom because of its many advantages; authorities foresee that 40 percent of post-war home lighting will involve fluorescent equipment.

Life hangs by such threads

WANTED: Something to keep flyers from freezing. So engineers developed electrically heated goggles, shoes, suits . . . Something dependable to guide pilots in fog and dark. So engineers devised electrically driven gyroscopic instruments. . . . Something automatic to keep engines from overheating or cooling. And now comes an electric control the pilot needn't touch.

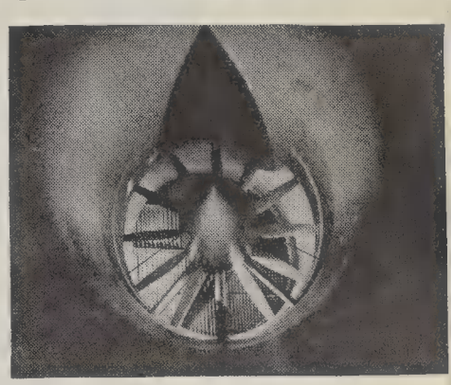
Working day and night, G. E.'s research and engineering staff has solved hundreds of such problems. The pictures here show how a few have been met. Through research come better electrical products and processes—in war or peace. *General Electric Company, Schenectady, N. Y.*





Flyers' lives often depend on their instruments. G-E workers use only tweezers to handle these precious parts of electrically driven gyroscopic instruments, dry them with air jets, oil them with hypodermic needles. They've *got* to be accurate.

Eyelids can freeze shut when you're 7 miles up! Electrically heated goggles, developed by G-E engineers, have fine wires embedded in plastic lenses. With G. E.'s electric blanket as a start, G-E engineers designed electrically heated flying suits, heated gloves and shoes being made in three G-E plants. Toughest problem was to devise heated gloves with thin wires strong enough to stand constant flexing.



• • •

Before it's built, they *know* how it will fly! 18,000 horsepower of G-E motors blow winds faster than a pursuit plane can fly. Testing model planes and parts *up to full size and speed* in wind tunnels like this helps get new airplanes perfected quicker.



Making night landings safer. Engineers adapted the G-E "Sealed Beam" auto headlamps into war use—G-E airplane landing lamps 20 times brighter than those on your car. Sealed against dust, dirt and salt water damage, they cut down the peril of high-speed landings.

★

Hear the G-E radio programs: *The G-E All-girl Orchestra*, Sunday 10 p.m. EWT, NBC—*The World Today* news, Monday through Friday 6:45 p.m. EWT, CBS—*The G-E House Party*, Monday through Friday 4:00 p.m. EWT, CBS.

GENERAL ELECTRIC

FOR VICTORY—BUY AND HOLD WAR BONDS

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of June, 1895)

METEOROLOGICAL BALLOONS — "A balloon equipped with self-registering instruments to measure the temperature and pressure of the atmosphere at high altitudes was recently experimented with in Berlin and came down with the instruments in good condition in Bosnia. The instrument showed that the balloon had reached an elevation of 53,872 feet, over 10 miles; the thermometer had fallen to 52 degrees below zero —the lowest it could record."

PROPELLERS — "It is interesting to learn from a paper read at the Institute of Civil Engineers by no less authorities than S. W. Barnaby and Thornycroft, that in their opinion the present speed attained by the screw propeller has in the fastest craft now afloat approached the limit of efficiency. The Marine Engineer says: It will soon be a question, therefore, if this view be correct, not as to the comparative merits of twin and triple screws, but as to the screw in comparison with other methods of propulsion. Here is a vast field for experiment and research."

SUN DAMAGE — "Sunlight can do incalculable damage to chemicals, pharmaceuticals, plush goods, and toilet articles in general, unless special precautions are taken to prevent its injurious action."

CAR CABLES — "The cable system of propelling cars has found favor in New York City . . . The cables come to the power house either entire or in sections in big spools weighing from 40 to 50 tons. The spools are transported by means of gigantic trucks, drawn by long strings of horses; in some cases twenty horses are attached to the truck."

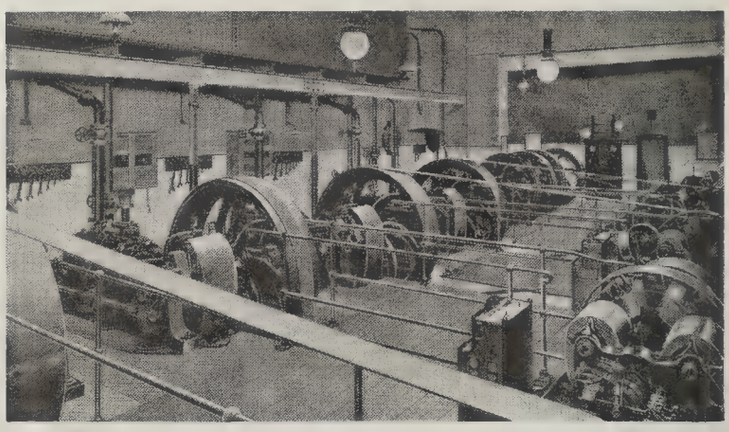
GLASS BRICKS — "Glass bricks, intended to be used in constructing the walls of plant houses and winter gardens, are made out of blown glass, and closed under 500° of heat. They possess internally a hollow of about one-third of their entire contents, which, being filled with rarefied air, acts as a non-conductor of heat. They are joined together with cement."

CANDLES — "The electric candle is in great request in England for the lighting and decoration of dining and other tables. An ingenious device for lighting the candles is provided by placing small pads under the table cloth, and taking the current from them by means of two pin points in the base of the candlestick. The candles, of course, are extinguished on being taken from the table, and are relighted when they are replaced in the proper position."

MOLTEN METAL — "The Cleveland Rolling Mills Company has just inaugurated a novel system of metal transportation. They ship great pots of molten metal from their central blast furnace to their Newburg mills, five miles away. The trip consumes fifteen minutes, and about 500 tons are carried daily over the tracks of the Erie Railroad. At the rolling mills the car is raised on a hoist to the mixer, the ladle is tipped by machinery and the metal poured into the mixer."

FILAMENT TEMPERATURE — "Prof. Weber has lately given the results of a number of experiments made by him to determine the temperatures of filaments in electric incandescent lamps. He has found that the normal temperatures of all species of incandescent lamps is approximately the same, and is comprised between 1,565° and 1,588° C. In the case of some lamps giving a very brilliant light—that is to say, with very thick filaments—the temperature is 40° higher."

GENERATING PLANT — "In connection with the new station, and the extensive alterations recently carried out at Leicester, the Midland Railway Company has put down the largest and most efficient electric plant driven by gas engines. We are enabled to give an illustration of the engine and dynamo room, and also a few particulars of the plant. The motive power consists of four large gas engines and two smaller, and all are made by Crossley Brothers, of Openshaw, Manchester. They are all built on their well-known lines, and are especially fitted for driving dynamos with the necessary steadiness. Each of the four large engines is of 25 nominal horse power, capable of giving off 40 brake horse power as a safe working load with Dowson gas . . . The engines run at two hundred revolutions per minute, and with the means adopted very great steadiness is obtained. The face of the flywheels is slightly rounded, and the dynamos are driven direct from it."



HORSE SHOES — "Among the recent patents is one for an aluminum horseshoe having finely divided particles of hard metal embedded in the wearing face of the shoe. This forms a very light shoe, of considerable durability."

BARGE TOWING — "Canal barges have recently been very successfully towed by electric power on the summit level of the Canal de Bourgogne. This portion of the canal is 3¾ miles long and has been made very narrow to reduce construction expenses. There is no tow path, and hauling is effected on the submerged chain principle. The hauling upon the chain is now done by electric power instead of by steam, as heretofore. A generating house has been fixed at each end of the section, the current being generated by water power."

VOTING MACHINE — "The days of ballot box stuffing and other modes of cheating at elections appear to be numbered. Inventive genius has provided machinery that will not lie and will not allow deception at the polls."

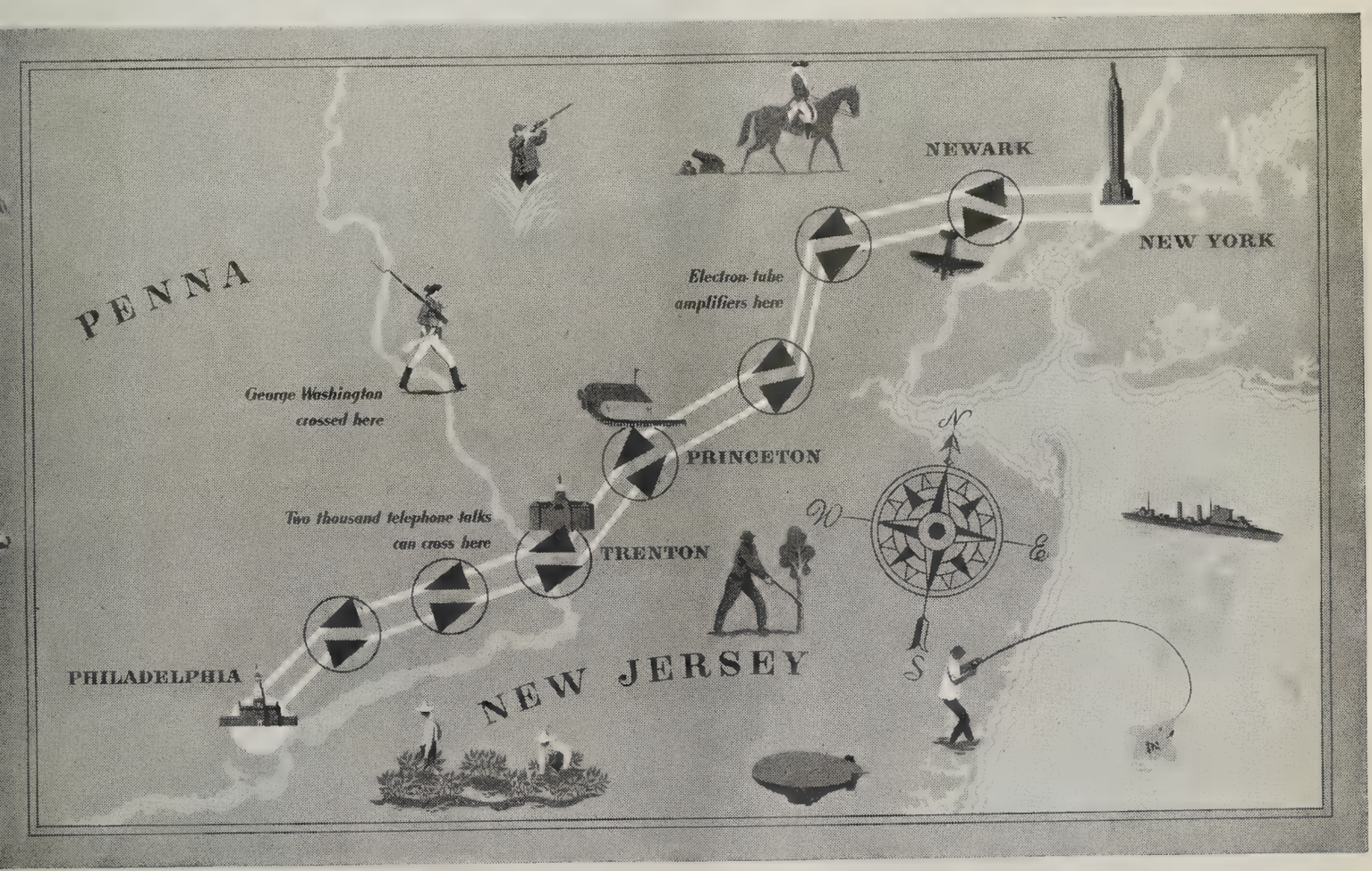
RAIL SPEED — "According to the 'Railroad Gazette,' the time made April 21 last, by the newspaper train from Camden, N. J., to Atlantic City, 58.3 miles, was 45¾ minutes, being an average rate of 76.46 miles per hour."

WATER POWER — "The chief problem in the conversion of water power into electrical power is that of regulating the flow of the water through the turbine wheels . . . One way of doing this was to have a man to regulate the flow by opening or closing the gates. This is, of course, impossible in a plant of any considerable size. Another contrivance employed a ball governor which automatically opened or closed the gates. This was a failure, because of the well known laws of inertia, and had a great tendency to race. Mr. Allan V. Garratt describes a very ingenious regulator whereby the gates were made to open or close, a little before the governor reached its highest or lowest point, thus obviating the chief defect of the older machine."

RUST-PROOFING — "The Gesner method of protecting iron and steel from rusting consists in forming on the surface of the metal treated a double carbide of hydrogen and iron, which is extremely hard and adhesive . . . The coating has a bluish color, and is stated to be so adherent to the metal that a treated bar can be bent through an angle of 45° without disturbing it."

90-MILE LABORATORY

for Telephone and Television



BETWEEN telephone offices in New York and Philadelphia once stretched a strange sort of laboratory. Most of the way it was underground; engineers made their measurements sometimes in manholes. It was a lead-sheathed cable containing two "coaxials" — each of them a wire supported in the center of a flexible copper tube the size of a lead pencil.

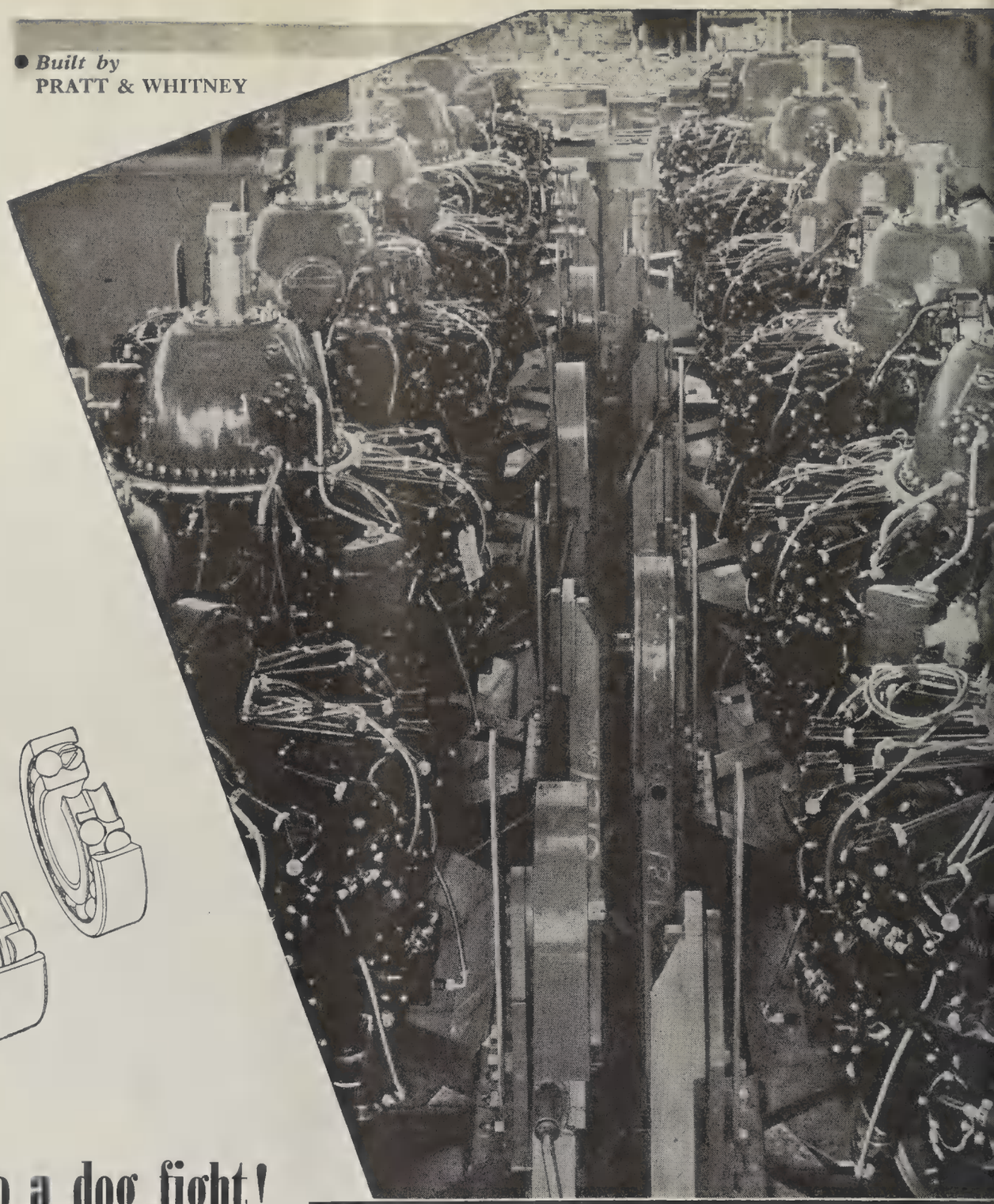
Theory had convinced engineers of Bell Laboratories that a coaxial could carry many more telephone talks than a full-sized voice frequency telephone cable; that it could carry adequately a television program. Experimental lengths were tested; terminal apparatus was designed and tried out. Finally, a full-sized trial was made with a system designed for 480 conversations. It was successful; in one demonstration people talked over a 3800-mile circuit looped back and forth. Now the cable is carrying some of the wartime flood of telephone calls between these two big cities.

This cable made television history also: through it in 1940 were brought spot news pictures of a political convention in Philadelphia to be broadcast from New York. Bell System contributions to television, which began with transmission from Washington to New York in 1927, have been laid aside for war work. When peace returns, a notable expansion of coaxial circuits is planned for both telephone and television in our Bell System work.

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● *Built by*
PRATT & WHITNEY



Prelude to a dog fight!

A squadron of these Double Wasps means a squadron of vicious fighters sweeping the skies clear of enemy planes. And as each of these engines is hoisted into the nose of a fighting plane, so are SKF Bearings on its vital parts. As the plane takes off and attacks at speeds of more than 400 m.p.h., the use of SKF's becomes apparent. Then, as never before, the safety, dependability and all-round good performance of SKF Bearings *count*. When an SKF flies, you can depend upon it . . . always.

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Scientific American
JUNE • 1945

* 100th Anniversary Year *



Official photograph, U. S. Army Air Corps
An early Curtiss pusher biplane in flight

Since Man Took Wings

By ALEXANDER KLEMIN

To Fly has been the Persistent Dream of Man Down through the Ages, and in the Present Epoch that Dream has been Completely Fulfilled, but with Greater Consequences of Destruction than of Good. It Remains for Man in the Future to Make Achievement of Flight Entirely Beneficial

THE HISTORY of aviation begins with myth and superstition, and ends with a rational application of nature's laws. In an Indian classic, Krishna's enemies build a winged chariot; Egyptian sculpture shows figures of winged men; and from the Greeks humanity inherits the story of Daedalus who made wings, and of his son, Icarus, who fastened them to his shoulders, flew too near the sun, and perished in the sea.

Later, in medieval times, desire sometimes achieved rudimentary attempts at flight. Death punished a Saracen for his boldness at the times of the Crusades, while Oliver, a monk of Malmesbury, England, perished in 1065 in an attempt at gliding.

Friar Roger Bacon made some striking speculations regarding flight in the 13th Century, but the first man who did more than speculate was Leonardo da Vinci (1452 to 1519), who made sketches of ornithopters, flew successful models of helicopters, and attempted an explanation of bird flight in terms of mechanics. One of his famous passages begins: "A bird is an instrument working according to mathematical laws, which instrument it is within the capacity of man to reproduce."

Passing over the centuries of more speculation—some pious, some fantastic—and more attempts at gliding, the human conquest of the air is found to be much closer in the latter half of the 18th Century when Cavendish discovered hydrogen, the light gas, which for so many years was the basis of lighter-than-air flight. It was on June 5, 1783, that the brothers Montgolfier sent up a rudimentary hot-air balloon which reached a height of 6000 feet and landed 7668 feet from its starting point. Only a few months later, on October 15, 1783, Francois Pilâtre de Rozier achieved the honor of being the first human to rise from the earth. While it is to the genius of France that we owe the inception of aerostatics and the parachute, the true beginnings of aviation are due to a number of English pioneers in the first half of the 19th Century.

First there came that great theorist, Sir George Caley, "The Father Of British Aeronautics" who, in a series of remarkable writings, recognized the aeronautical advantages of curved surfaces and the necessity of providing both vertical and horizontal rudders. He also suggested reasonable methods for calculation of propelling power and experimented with a fixed surface glider. His contemporary, Thomas Walker, a portrait painter of Hull, attained almost equal fame through his pamphlet on the "Art of Flying," published in 1810.

After Caley and Walker, men passed from theory to experiment. W. S. Henson, as early as 1940, experimented with



The Curtiss "June Bug" that won the first leg of the Scientific American trophy on July 4, 1908

model gliders and light steam engines. From 1846 to 1848, John Stringfellow worked on a remarkable contrivance, the first engine-driven airplane which actually flew. The model had an eight-foot span, and weighed eight pounds with engine; its design and construction seems reasonable in light of today's knowledge.

FAMOUS NAMES—The latter half of the 19th Century produced equally famous names. Penaud, a Frenchman, in his well-known patent of 1876, anticipated and described almost every feature of the modern airplane. The Germans first took their place in the development of aviation when Otto Lilienthal, with his brother Gustav, undertook to learn the art of the birds by practicing with a man-carrying glider. Lilienthal, in almost 30 years of experimentation, secured glides where the angle of descent was only 1 in 10, and built up a remarkable body of aerodynamic knowledge, particularly in relation to control. His work began in 1867 and ended with a fatal accident in 1896 when he was turning to powered flight.

Lilienthal accomplished much, and the Englishman, Pilcher, followed grandly in his footsteps. Professor Montgomery of California employed gliders launched from balloons and wrote a patent which showed remarkable understanding. Ader claimed actual flight before generals of the French Army in his "Avion" on October 14, 1897, though the official account speaks only of short hops. In the United States, Chanute, a civil engineer, advanced the design of the glider with his trussed biplane, and Sir Hiram Maxim's giant steam-powered airplane almost achieved flight in 1894.

What had these pioneers done? Nothing, in one respect, because they had not flown; almost everything, on the other hand, because they had laid solid foundations for the work of the Wrights.

UNLUCKY LANGLEY—Before the Wright brothers there came the brilliant and painstaking work of S. P. Langley, who began his studies when a middle-aged man with an established reputation as an astronomer. With the aid of a large whirling arm and rubber driven models, Langley did a vast amount of aerodynamic research; his "Memoir on Mechanical Flight," and his "Experiments in Aerodynamics," published in 1891, are classics. Granted a congressional appropriation, and with the help of a young engineer, Charles Manly, he finally constructed the "aerodrome" which he described as "built of steel, weighing complete about 730 pounds, supported by 1040 feet of sustaining surface, having two propellers driven by a gas engine, developing continuously over 50 brake horsepower." The aerodrome was seriously damaged in the launching on December 8, 1903. Manly escaped uninjured, but in the face of public disapproval and the inability to secure further funds, Langley did no more. Some years later, Glenn Curtiss succeeded in flying the aerodrome, but only after important modifications had been made in it.

The fact remains that it was the Wright brothers who first achieved powered flight at Kitty Hawk, North Carolina, on December 17, 1903. The Smithsonian Institution has finally retracted its hostile views on this flight and, once the war is over, the Wright biplane will probably be brought back to the United States from the South Kensington Museum in London, where it has been sheltered all too long.

Since there is a Wright celebration every December 17th, only a brief personal appreciation will be attempted here, drawn partly from personal acquaintance. The Wright brothers learned all they could from Lilienthal and from the English pioneers, frequently consulted Chanute, and carefully studied Langley's writings. It was a mark of greatness that they were willing to learn from others; nevertheless they were not men of little education, as has sometimes been said. Though they never matriculated at a university, and their calling in life was that of bicycle-makers on a modest scale, they were true scientists who carried out their long experiments with a well-defined goal and perfect objectivity.

The Wright brothers' experiments in a small two-foot wind tunnel stand substantially correct to this day, and were followed by the flying of kites and gliders, giving a solid background for building their first powered model. Workers before them had seen parts of the truth; the Wrights saw the truth as a whole, and in one design combined curved wings, control about all three axes, reasonable stability, a correctly designed propeller, and a practical gasoline engine.

MAN COULD FLY—The flight at Kitty Hawk ended all uncertainty as to whether or not man could fly. Now came an era of energetic but poorly guided development, a period of excitement and adventure. The Wright brothers, neglected and held in some suspicion because of their policy of secrecy, persisted in almost unaided effort. Their third model, in 1905, embodied the joy stick for control and flew a distance of 24 miles instead of the record of 852 feet as of 1903. Few followed in their footsteps in the United States, but France gave to aviation history names such as Blériot, Esnault-Pelterie, Ferber, Santos-Dumont, Voisin, Farman, and others.

The United States Army gave the subject of early heavier-than-air flight no acknowledgment. It was only when President Theodore Roosevelt saw a description of the Wright Flyer in an issue of Scientific American in 1907, and asked Secretary of War Taft to look into the matter, that the Chief of the Signal Corps drew up a specification and asked for bids.

The first American Army officer to lose his life in an airplane was Lieutenant Thomas E. Selfridge, killed at Fort Myer, Virginia, at a test of the Wright model, while Orville Wright, who was piloting, was badly injured. Nevertheless,

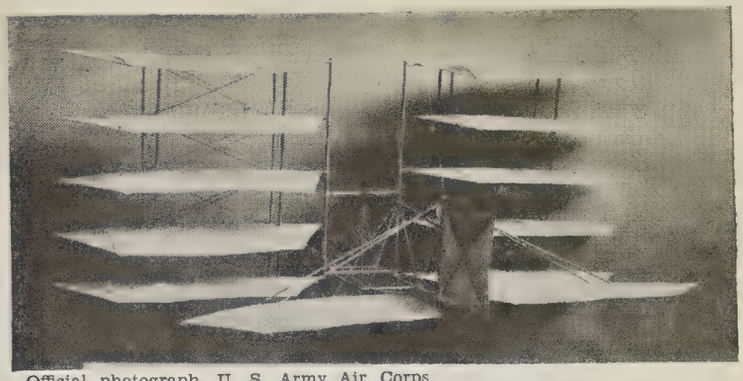
in 1909, the Wrights received a $25,000 award and a bonus for improving on the minimum speed requirements. With the winning of a suit started in 1910 against the Herring-Curtiss Company, the Wrights established their fortunes on a substantial basis though they never became as wealthy as their genius warranted.

The early days of aviation were wonderful for the pioneers, not always burdened with scientific knowledge but ever willing to take a chance; here was an era of adventure, of barnstorming, of rewards for records which look very modest today. Glenn L. Martin, exhibition pilot and barnstormer, was at the threshold of his career in airplane manufacturing. Glenn H. Curtiss, a bicycle maker like the Wrights, did many things with a few workmen in his shop at Hammondsport, New York. His "June Bug" won the Scientific American trophy on July 4, 1908, for flying two thousand yards over an S-shaped course at a speed of 39 miles an hour. In France, Louis Blériot flew across the English Channel on July 25, 1909, winning a prize offered by the *London Daily Mail*. The Army continued to give grudging acceptance to the airplane, with the Signal Corps still responsible for all aviation activity. In 1910, Lieutenant Ely flew off the deck of an armored cruiser, the U.S.S. *Birmingham*, in Hampton Roads, and two months later alighted on the deck of the U.S.S. *Pennsylvania*.

But these adventurous days had disadvantages. Without development, really practical aircraft could not be achieved, and lack of patronage for the flimsy aircraft available made it difficult to raise needed money. American aviation was virtually at an impasse.

WAR TURNS THE TRICK—World War I changed the situation completely. At the Hague Peace Conference of 1899, it was voted that no aerial vehicle was to take part in warfare, but the Peace Conference of 1907 was less positive, and airplanes were destined to become increasingly important in war. At the outbreak of World War I, France had 1500 airplanes; Germany had 1000; England had a lesser number in keeping with its smaller army, and the United States, true to its general traditions of never preparing for war, had only 50 men and 6 planes in its air force.

The small group of devoted officers within the United States Signal Corps could do little to foster military aviation. Nevertheless, the course of the war provided them with convincing arguments in favor of the use of planes in fighting wars. Thus, during the Battle of Mons, August 23-26, 1914, Sir John French, the British Commander, was able to save his armies by retreat when his few reconnaissance planes, and they alone, warned him that the French forces had given way on his right flank. It was then established that the airplane could be a valuable method of military reconnaissance.



Official photograph, U. S. Army Air Corps

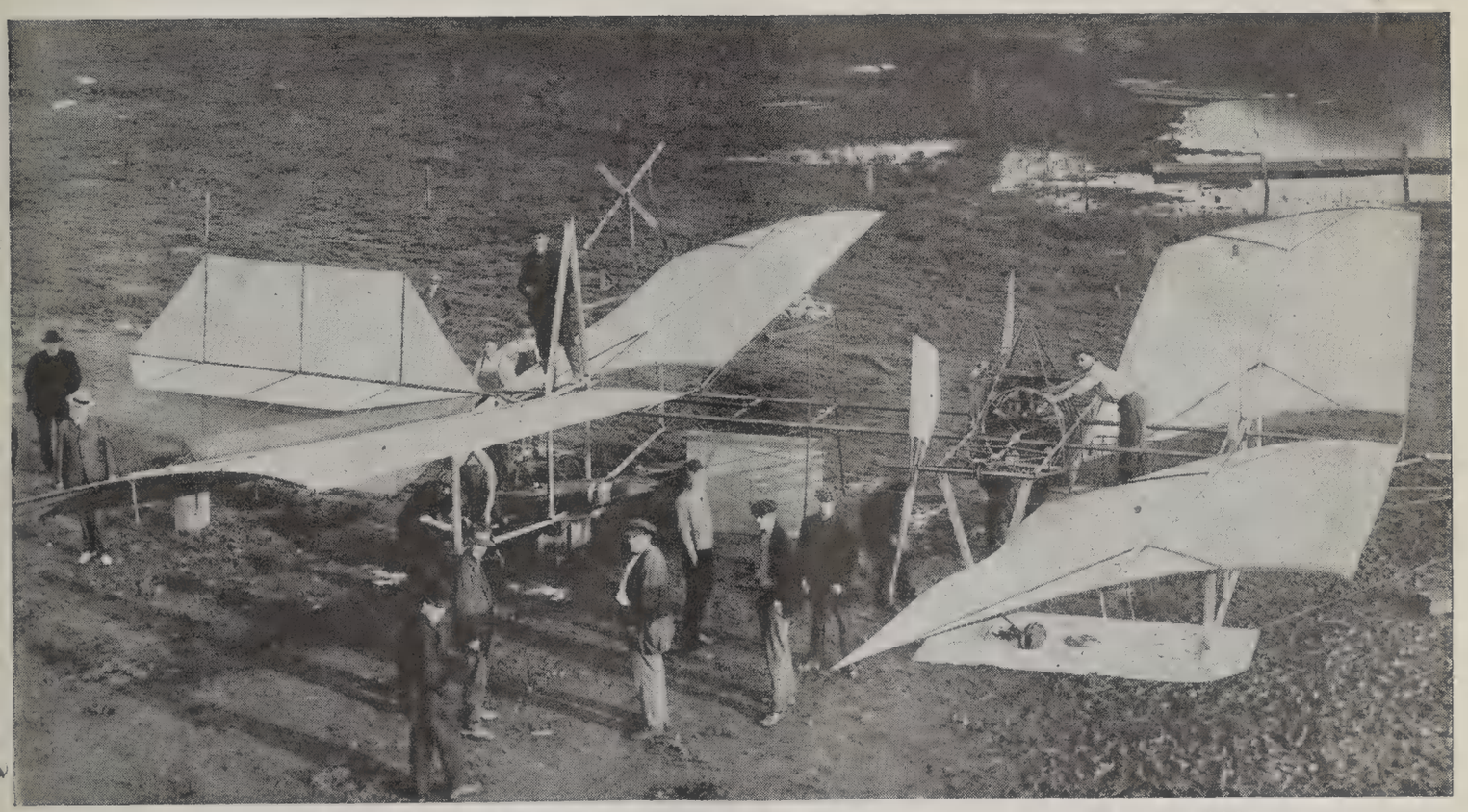
A glider built by Octave Chanute, an American, who did considerable gliding experimentation about 1895

World War I was to teach other lessons in the uses of aviation. Aerial photography proved invaluable in securing and conveying information. Aerobatics were limited at the start of the war, and the spin was considered deadly. Beginning with the discovery of the Immelman turn, a whole series of maneuvers were developed for aerial dogfights or for disengaging from the enemy. The power of disciplined formations was soon learned by the Germans, with the noted Von Richthofen squadron playing havoc with the Allies who considered formation attack against a single flier unsportsmanlike.

The war in the air began with an exchange of harmless revolver shots between a French and a German aviator, and the dropping of a sandbag on Paris, asking for its surrender. Early use of fléchettes, small deadly pointed arrows, soon gave way to more deadly explosive bombs. Reconnaissance was first performed at low altitudes because anti-aircraft fire was harmless above 3000 feet; later anti-aircraft guns were made effective at heights of 25,000 feet, which necessitated higher ceilings for combat planes.

The war started with planes of 80 horsepower, with top speeds of 70 miles an hour, and much stability. It ended with combat planes capable of some 150 or more miles an hour, with 400-horsepower Liberty motors installed in the De Havilland two-seater fighters, and with stability giving way to streamlining and maneuverability.

The United States soon abandoned the notion that our air force could be a subsidiary branch of the Signal Corps, and



Glenn Curtiss re-conditioning Langley's original Aerodrome for a test flight in 1914

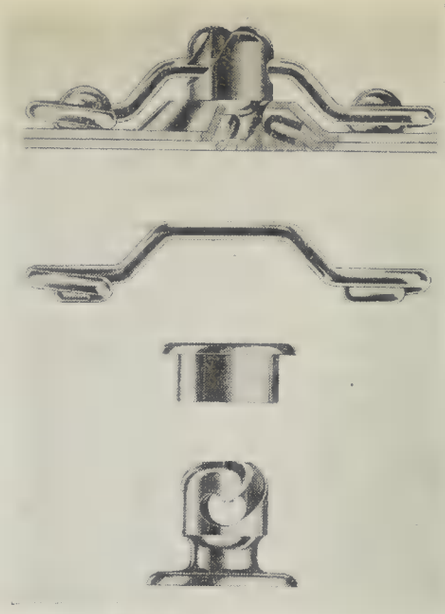
ended the war with 14,330 officers and 124,767 enlisted men in this service. In spite of great mistakes in handling war production, we built 3288 combat airplanes and many more training craft. The Liberty motor, said to have been designed in a few weeks in a Washington hotel, was ready for delivery at the rate of 10,000 a month at the signing of the Armistice.

The American plane manufacturers, who had almost lost hope before 1914, emerged from the war as powerful companies, thanks to early orders from the British and French for Curtiss "Jennies," and from our own forces later. But because Americans could improvise, Congress was encouraged to slash Air Service appropriations to the minimum when peace had come. Congress, neglecting to read the signs of the times, failed to realize that aerial supremacy could, in a war, sway from side to side rapidly, and that such superiority was not a question of heroism, but a matter depending upon which side developed better airplanes.

From 1914 to 1916, the Germans ruled in the skies because their Taube was so superior to the slow British BE 2C's and the 80-horsepower Vosins and Farmans of the French. When the British replaced their earlier craft with the SE 5's equipped with the more powerful Hispano-Suiza engines, and the French developed the fast and maneuverable Nieuports, the advantage passed over to the Allies. Then because Anthony Fokker, the Dutch designer, built a semi-cantilever biplane powered with sturdy and reliable Benz and Mercedes engines, and having wonderful maneuverability, Allied aviators were almost swept from the skies.

The ending of the war brought a shrinkage of the aviation industry. Congress cut air service appropriations drastically. So much surplus material came on the market that a flier could buy a two-place "Jenny" for $50 and a Curtiss OX-5 engine of 90-horsepower for $30. Few military and naval aircraft were built. The brass hats fought Brigadier General William E. Mitchell, who in 1921 sank two old battleships by aerial bombing, and forced him to resign in August, 1926, after a court-martial. In some years not more than a dozen commercial airplanes were built.

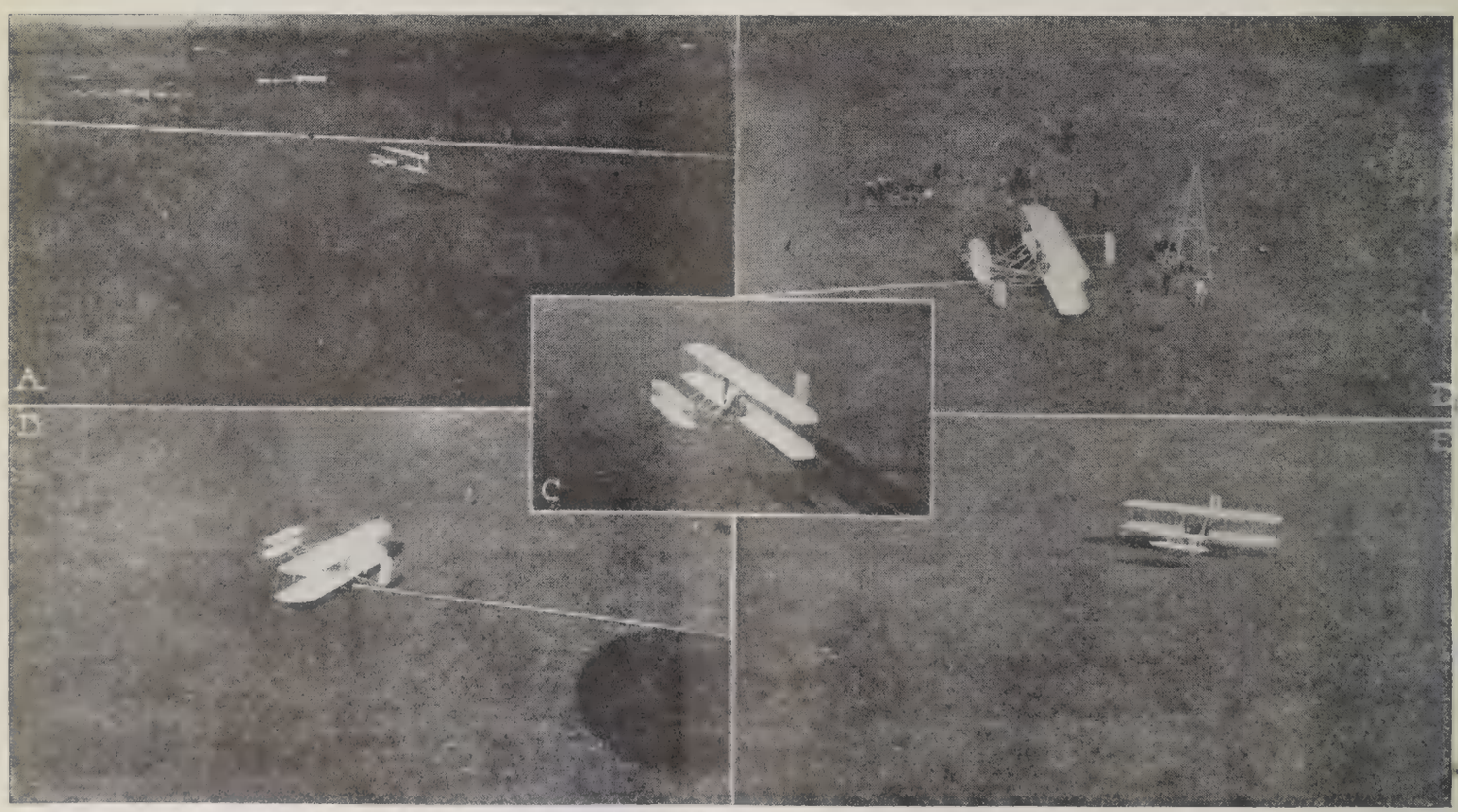
THE MAIL GROWS WINGS—Yet there were signs of the later triumph of civil aviation. Most important of these was the establishment of the United States Air Mail Service. Using roughly converted DH-4's, the Post Office established the first service between New York City and Washington on May 15, 1918. Other large cities were similarly connected, and the years 1920 and 1921 brought the establishment of the transcontinental air mail. On July 1, 1924, a regular night service, over a beacon-lighted airway, came into being between Cheyenne, Wyoming, and Chicago, Illinois. With war equipment and few aids to navigation, the Post Office offered dependable service that was, at the same time, an experimental laboratory for the commercial transport services to come later.



An excellent example of the many accessories that have been developed for airplanes is the Dzus spiral cam fastener. The fastener, used for holding cowls, access doors, and the like, is quick acting and consists of a rotatable stud portion having a spiral cam at the end which engages with a permanently mounted spring

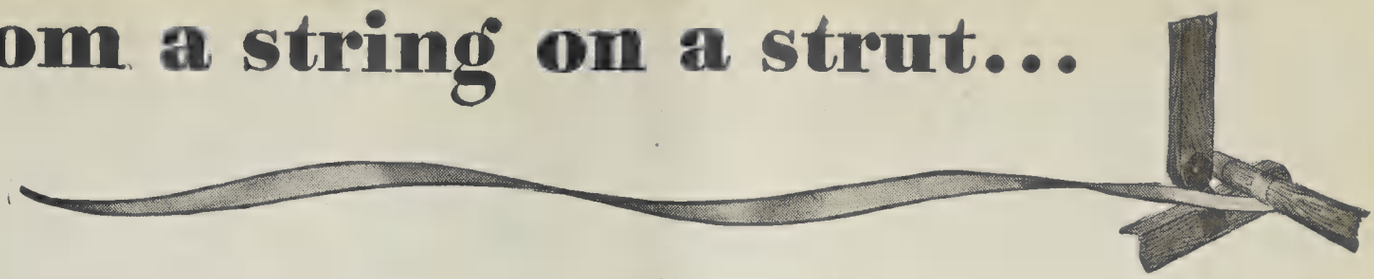
SPANNING OCEANS—Another significant feature of the years after the Armistice was a number of remarkable flight records. These emphasized that the conquest of the air was proceeding rapidly, and they furthered the acceptance of civil aviation by the public. The first great achievement was the transatlantic flight by the Navy's NC-4, a flying boat of some 28,500 pounds gross weight, with Lt. Cmdr. Albert Cushing in charge. The NC-4 took off at Trepassy Bay, Newfoundland, on May 16, 1919, and with stops in the Azores and Portugal arrived in Plymouth, England, on May 31st after a flight of 4514 miles. The flight foreshadowed the time when the Atlantic would be fully mastered. The NC-4 had the benefit of the Navy's whole organization, with supporting vessels to lessen the hazards of the trip, and carried a fairly large crew.

Sir John Alcock and Sir Arthur Whitten-Brown, with no support, showed even greater daring. Flying a Vickers-Vimy biplane powered by two Rolls-Royce engines, they



A series of photographs, 1909, showing a Wright biplane taking off and in flight. A starting rail was used

From a string on a strut...



To this...



Instrument panel of a Sperry "flying laboratory" showing the last word in modern flight instrumentation.

IN THE EARLIEST days of aviation, airplanes had no instruments—and a pilot flew "by the seat of his pants."



Sometimes aviators tied a piece of string to a strut. In normal flight it whipped straight back. If the string deflected to one side it indicated that the plane was slipping sidewise. But mostly they flew by the feel of the wind in their faces, and by direct observation of the ground and the horizon.

In 1914, at the beginning of World War I, flight instruments began to appear. One of the first was the Sperry Magnetic Compass for instrument panel mounting—a big improvement over former compasses of the marine type which were placed on the floor of the cockpit.

The Sperry Turn Indicator was introduced in 1918. It was so basic in design that practically every airplane that flies today carries an instrument of that type. A few years later another basic flight instrument appeared on instrument panels—the Sperry Directional Gyro. Being non-magnetic, it eliminated the swaying needle and magnetic error of the usual compass, and is still found among the dozens of amazingly accurate flight instruments on which pilots depend today.

Sperry flight research has grown many times over, and it embraces the new science of electronics in many of its projects. Under the stimulus of wartime demand, new devices have been developed in record-breaking time—and in record-breaking numbers.



Sperry engineers testing intricate flight instruments in a "flying laboratory"

Many of these developments are secret. But it is one of the few compensations of war that many of them will someday be adapted to peacetime use: Radar . . . automatic flying devices . . . new types of compasses such as the Gyrosyn . . . the Attitude Indicator . . . instrument landing systems . . . airport traffic control instruments . . . and many others.

When that time arrives, Sperry's research laboratories will tackle the task of making peacetime flying safer, swifter, more economical, and more comfortable.

WAR BONDS—TO HAVE AND TO HOLD!

SPERRY

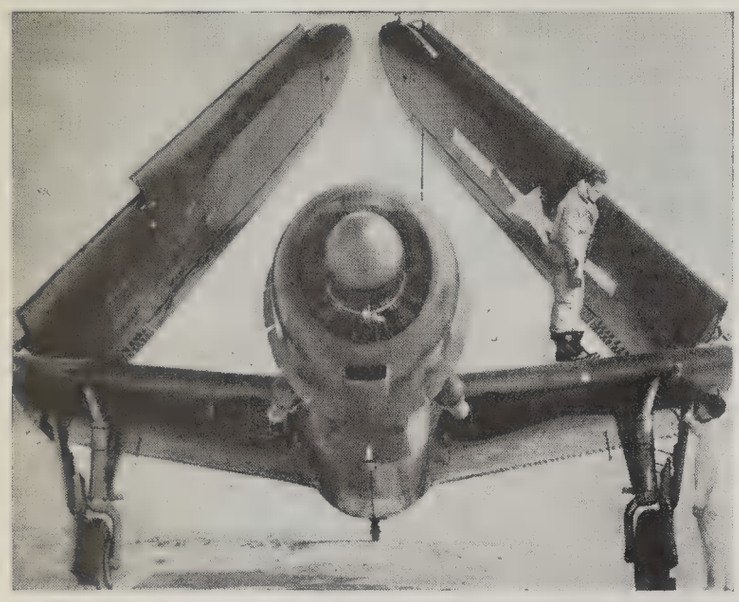
CORPORATION

30 Rockefeller Plaza, New York 20

FORD INSTRUMENT CO., INC.
SPERRY GYROSCOPE CO., INC.
VICKERS INCORPORATED
Waterbury Tool Division, VICKERS INC.

left St. John's, Newfoundland, on June 14, 1919 and arrived at Clifden, Ireland, on June 15, flying 1960 miles in 16 hours and 12 minutes, with fog and clouds imposing blind flying on them for part of the way. In another fine achievement, Lieutenant John A. MacReady, U.S.A., flew non-stop coast-to-coast on May 2-3, 1923, a precursor of transcontinental services to come later. Major Al Williams made a speed record of 266.59 miles an hour on November 4, 1923, in a Curtiss Racer Biplane, which emphasized the tremendous advance in speed that had been achieved since early days. Transatlantic flights from east to west were long unsuccessful because of contrary winds, and casualties in the North Atlantic were frequent.

Then there came the world's most famous flight. Charles Augustus Lindbergh left Mineola, Long Island, on May 20, 1927, and landed at Le Bourget, the Paris airport, on the evening of May 21, 1927, after covering 3605 miles in 33 hours and 39 minutes. He flew alone in the "Spirit of St. Louis," a small monoplane, heavily overloaded with gas. Carrying a few sandwiches and little special equipment, he succeeded because of courage, careful preparation, and an innate flying and navigational ability such as few have. A wave of enthusiasm swept the world when the great news was broadcast. That an American boy had succeeded single-handed, with little help from others, in crossing the wide ocean, renewed faith in the future of aviation, and contributed more to the public support of flying than any other single event. It has sometimes been said that Lindbergh did little for the conquest of the Atlantic compared with the meticulous survey flights of Pan American Airways. True—but morale may count even more than technical preparation. Lindbergh was soon followed by Chamberlain who,



Folding wings, such as on Curtiss Helldivers, have greatly increased aircraft carrier effectiveness

with his passenger Levine, almost reached Berlin from New York; and by Admiral Byrd who reached France after many mishaps.

Meanwhile, it was becoming apparent that air transport in the United States would be on a sounder footing if air mail were placed in the hands of private contractors who could provide passenger facilities and thus lessen the cost of air mail to the nation. Accordingly, February 2, 1925, passage of the Kelly Bill provided for the transference of air-mail operation to private contractors. This meant that the small, poorly organized, struggling air services could grow into well-financed organizations of national importance. There was another helpful factor in the situation. William B. Stout had designed and built, with the support of Henry Ford, the Ford tri-motor. Mr. Ford was so impressed with this excellent ship that he manufactured them on a scale large for that day, and was content to produce them at a substantial loss.

FIRST AIR FREIGHTERS—On April 3, 1925, Ford began an air service out of Detroit to Chicago and Cleveland, carrying his own freight exclusively, but operating with the regularity of a public carrier; and the experience gained with



One of the Douglas super-clippers, on order by Pan-American Airways, that will carry 108 passengers

the tri-motor was to serve others. By 1926, air-mail routes had been awarded under the terms of the Kelly Act, and stronger companies began to emerge such as National Air Transport, capitalized at $10,500,000, with the support of such personalities as Howard E. Coffin of Hudson Automobile; Colonel Paul Henderson, sometime Assistant Postmaster General and "Father of the Night Mail"; Philip Wrigley; William A. Rockefeller; Charles A. Lawrance; and other distinguished men.

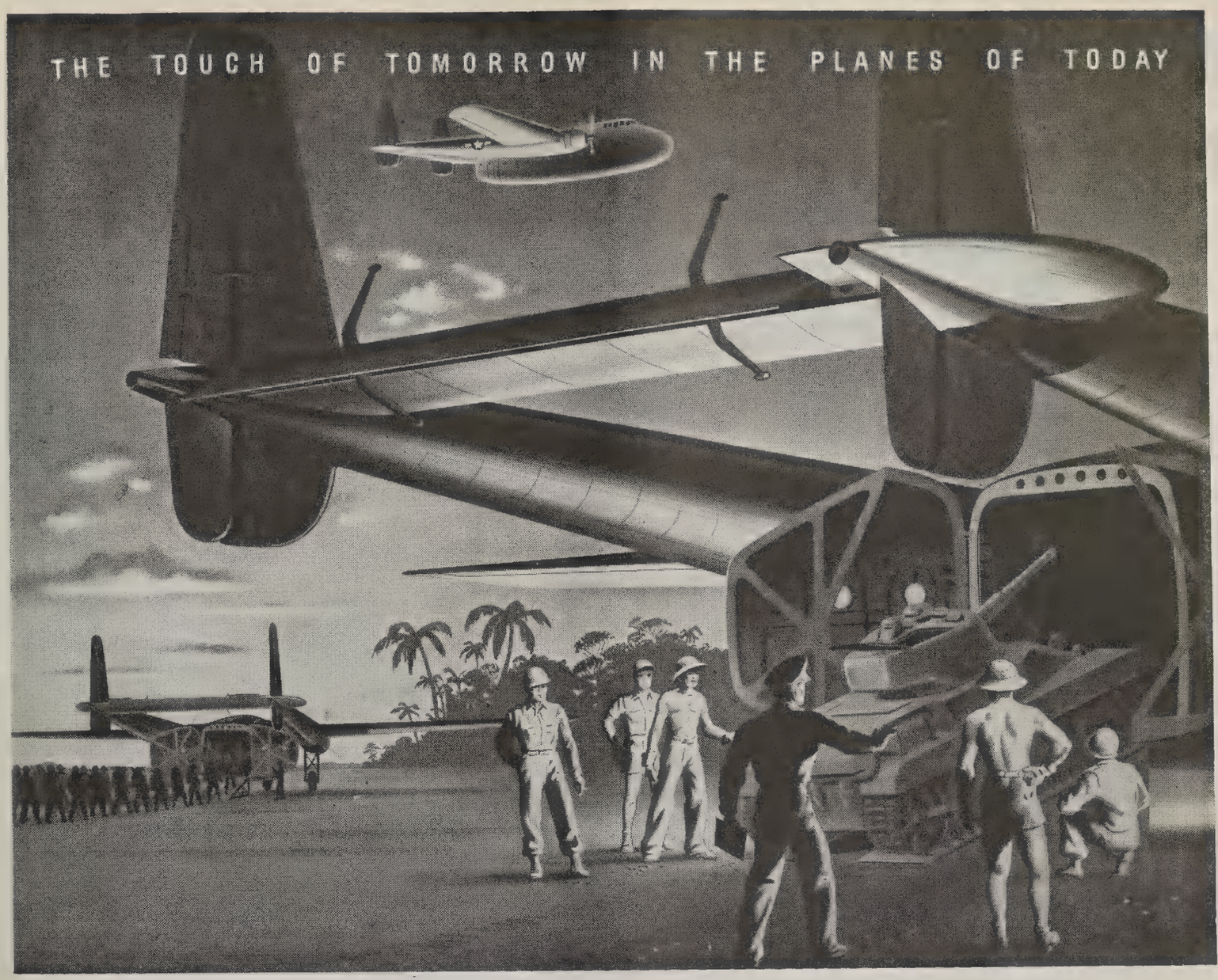
The Air Commerce Act of 1926 became the legislative cornerstone of civil aviation. An Aeronautics branch was set up in the Department of Commerce, and William P. MacCracken, Jr., was appointed Assistant Secretary of Commerce for Aviation. He did excellent work in regulation and in the construction of airways. Later came the organization of such widely known airlines as United, Transcontinental, and American Airways. The airlines grew in the amount of mail and number of passengers carried. They lost money, but their backers were apparently satisfied that they were laying foundations for the future.

Trouble later arose, however, over air-mail contracts allocated in 1930 by Postmaster General Brown. They were canceled in 1934 by Postmaster General Farley on the ground that the fees allowed the companies were excessive. President Roosevelt ordered the Army to carry the mail. But the young Army pilots were unfitted to fly mail planes in all weathers and at night, and many planes and lives were lost. Finally, the President ordered the air mail returned to the same private contractors on a different basis. On August 22-23, 1938, the Civil Aeronautics Act was passed, creating an authority for civil aviation and helping the industry grow still faster in mileage, in passengers carried, in navigational aids, in air traffic control, and in safety. When World War II overtook the United States, the Air Transport Command profited by being able to draw on the skill, experience, and personnel of the airlines to carry supplies and munitions to the far corners of the world.

FLIGHT LABORATORIES—Aviation research deserves as high a place in the annals as air transport, and provides an equally interesting story. Both Langley and the Wrights placed reliance on laboratory methods, and set a tradition of aerodynamic research that has been followed ever since. But just as the United States neglected the airplane in the country of its birth, so America allowed Europe for many years to lead in scientific progress. The first really well-equipped aerodynamic laboratory was that of Eiffel, the builder of the famous tower, who built a wind tunnel in Paris with his own funds and accumulated much aerodynamic information, being most active between the years of 1910 and 1916.

The English did fine work at the National Physical Laboratory, and issued the first reports and memoranda of the British Aeronautical Research Committee in 1909. It was in these early reports that Lord Rayleigh applied the theory of dynamic similarity to the interpretation of model aeronautics.

The Germans, prior to World War I, were concerned greatly with the theory of aerostatics. During the war they converted the vortex theory, established by Lanchester, an



Loads for a Landing on Nippon

Into the spacious hold of the Packet will go lethal cargoes —destination Japan. Guns, light tanks, shells, trucks or paratroopers; material and men for victory in the Pacific will be airborne in the Army's "flying boxcar," the new cargo carrier designed by Fairchild and built by Fairchild and North American Aviation.

The Packet, first airplane produced *specifically* for cargo transport, can carry up to nine tons. Its range, with lighter loads, is more than 3,500 miles.

Forty-two paratroopers with full equipment can be "delivered" through two jump doors in the stern, clear of any obstruction. An ingenious device sends equipment parachuting through special doors in the belly, simultaneously with each paratrooper's jump.

The Packet is loaded with extreme ease. Its fuselage floor is level and at standard truck-floor height. Cargo capacity is 2,312 cubic feet—about 88 per cent of the capacity of a standard railroad boxcar.

This all-metal, twin-engine, flying boxcar possesses characteristics inherent in all Fairchild products, "the touch of tomorrow in the planes of today." With but minor modifications it will become an efficient and profitable carrier of cargo in peacetime commerce, the flying boxcar of the new air age.

BUY U. S. WAR BONDS AND STAMPS

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Ranger Aircraft Engines Division, Farmingdale, L. I. · Fairchild Aircraft Division, Hagerstown, Md. · Duramold Division, Jamestown, N. Y.

Subsidiary: Al-Fin Corporation, New York, N. Y. · Affiliate: Stratos Corporation, New York, N. Y.

Englishman, into the Prandtl vortex theory, giving it, however, sounder exposition and application.

In Russia, Joukowski discovered the theory of the circulation of lift quite early, though Kutta in Germany seems to have made the same discovery independently at about the same time. Prandtl and his associates at Goettingen led in aerodynamics for a good many years until German science deteriorated under the Nazis.

In the United States, a historic date in aerodynamic research was the passing of an Act of Congress on June 30, 1916, by which there was established the National Advisory Committee for Aeronautics. The NACA soon after established a Memorial Laboratory at Langley Field, Virginia, which has remained in the lead ever since, approached but never equalled by the Deutsche Versuchsanstalt fiër Luftfahrt near Berlin, the French laboratories at Chalais-Meudon, and Guidonia, the aeronautical research city built by Mussolini near Rome.

Research at Langley Field has been marked by such achievements as the first full-scale wind tunnel, the first compressed-air wind tunnel, the development of the NACA cowl for air-cooled engines, the laminar flow wing, and studies of high-speed compressibility effects. The Army station at McCook Field, Dayton, Ohio, established in 1917, and its successor, Wright Field, have originated little, but have served to point out to industry the requirements of military aviation, and have provided magnificent testing facilities.

During World War II, Wright Field has grown to enormous proportions in personnel, with huge high-speed laboratories, test stands for engines of more than 3000 horsepower, and the most complex equipment for full-flight testing. The Philadelphia Naval Aircraft Factory and the National Bureau of Standards are other government institutions contributing to aviation research. In aeronautical education, the United States has always led. It began on an important scale when Daniel Guggenheim endowed in 1925 the Guggenheim School of Aeronautics at New York University. A few months later the Daniel Guggenheim Fund for the Promotion of Aeronautics was established. Under its auspices there were endowed successively Guggenheim schools or laboratories at the Massachusetts Institute of Technology, the California Institute of Technology, Stanford University, the University of Michigan, and the University of Washington.

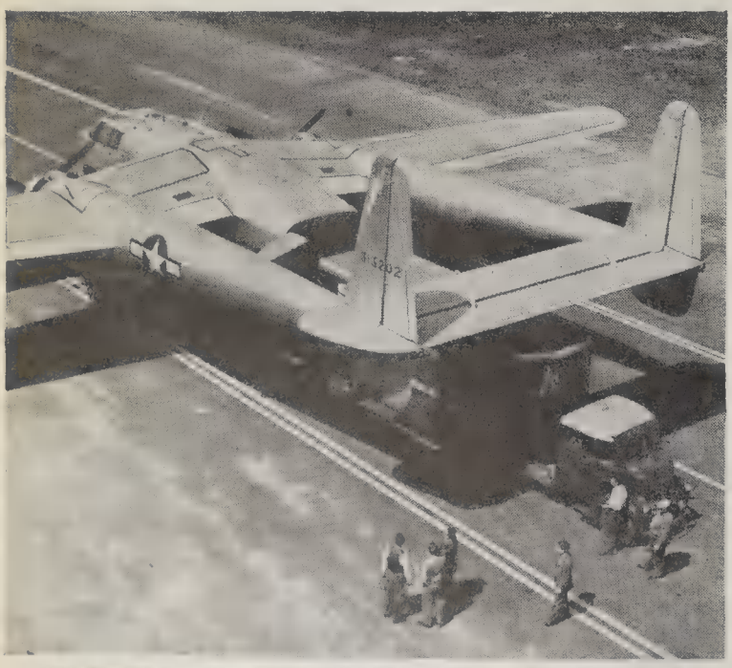
INDUSTRY'S CONTRIBUTION—Invention and development of the airplane as well as engines, accessories, and instruments have been a matter of American industry. Never has American genius manifested itself in so many varied and versatile ways as in the promotion of the American aviation industry from its beginning with the Wright biplane to the production of the giant B-29 and the jet-propelled Lockheed "Shooting Star." Manly's 50-horsepower engine has been succeeded by 18-cylinder, two-row, air-cooled giants developing well in excess of 2200 horsepower.

In this connection, it is interesting to recall a few famous names. Charles L. Lawrance, who began his work in a small loft factory in the early 1920's, is certainly the father of the American air-cooled engine. Elmer Sperry invented the automatic stabilizer now installed on every airliner and bomber. Douglas, who entered aviation as an engineer, has become one of our leading manufacturers; his Douglas DC-3 airliners have been used in greater numbers on the airlines than any other craft. Dr. Sanford Moss is worthy of special praise because his work on superchargers made it easier to build turbo-jets.

Two of the many companies that have contributed to the common advance are Bendix Aviation, with innumerable accessories and instruments to its credit, and Aluminum Corporation of America which did fine work in fostering modern construction in light aluminum alloys.



Thousands of Army pilots received their first training in the sturdy, dependable Fairchild PT-19. More than 10,000 primary trainers of this design were manufactured by Fairchild and four other contractors. Nine other United Nations have used the PT-19 for training. The two-place plane has a top speed of 125 miles an hour and climbs 655 feet a minute



Air-freight operations of the future are foreshadowed in this view of the Army's newest cargo plane, the Fairchild C-82 Packet. Design is such that huge trucks and vans can back right up to the entrance of the cargo hold. Direct loading and unloading are possible because the floor of the hold is level and at truck-bed height. The Packet can carry 2312 cubic feet of cargo weighing nine tons

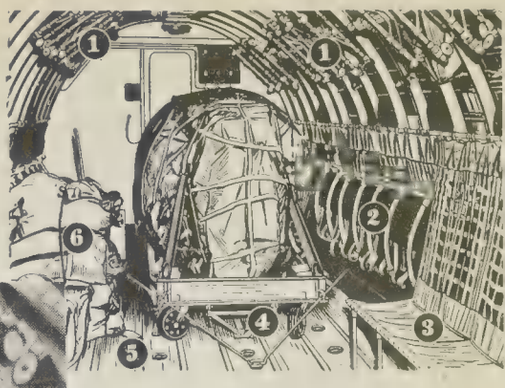
In the field of accessories, there are Fairchild Camera, Dzus Cowl Fasteners, Boots, Elastic Stop Nuts, Cleveland Pneumatic Oleo Shock Struts, and many others.

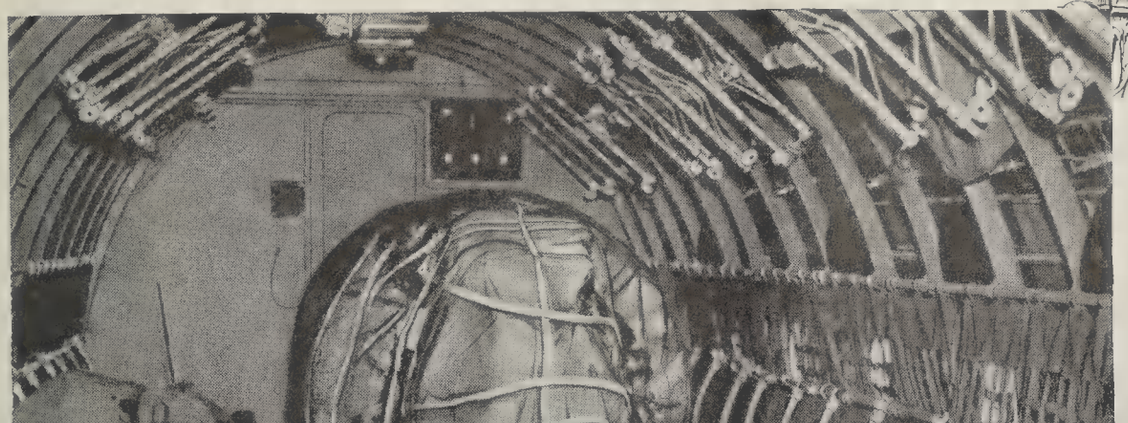
Modern military aviation is an immense subject in itself. From the fléchette of 1915, military destruction from the air has come to the 11-ton volcano bomb; from the revolver and light machine gun of World War I it has developed to the point where the massed rocket guns of a combat airplane are equal in fire power to the broadsides of a light cruiser. Military aviation has not won the war but superiority in air power has been necessary to bring victory in sight. Without it, the United Nations could never beat Germany and Japan.

For the future, it can be said that World War II has given impetus to build faster and larger transports, that jet engines will eventually drive civil aircraft through the air at supersonic speeds, that radar will conquer fog and darkness.

Humanity is truly entering on the Air Age which will push the science of transportation to unforeseen achievements or else bring modern civilization to complete ruin. The alternatives depend on whether the ever-growing power of aviation for good or for evil can be controlled and directed into those channels which will lead to the most effective utilization of its possible benefits.

EVANS SKY PRODUCTS





1 Sky Litter stanchions and supports folded back.

2 Sky Seats folded back.

3 Sky Seat ready for use.

4 Evans Rod-and-hook tie-down equipment in use.

5 Evans Sky Floor with sockets for litter stanchions and rings for Skyloader hooks.

6 Rope tie-down equipment in use with other cargo.

Air Transportation Rides the Beam to a Bright Future

The rapid development of Evans Sky Products in the past few years due to war's demands promises many new ideas in post-war air transportation. For, thanks to the adaptability of Evans Sky Floors and other Sky Products, a transport plane can quickly be changed from a cargo-carrier to a passenger plane, or can be used to carry both cargo and passengers at the same time, depending upon the waiting load.

Airline operators will thus be able to render better service, keep certain types of planes operating profitably and "in the air" more hours per day. And the air-traveling public and shippers of air-cargo of all kinds, shapes and sizes will benefit from more flexible flying service at lower cost.

Evans engineers are planning for even greater future progress in Sky Progress . . . and their services are always available to airplane manufacturers and airline operators. Write for the latest issue of "Sky Loadown"—an informative illustrated publication you'll be sure to find interesting.

In the AAFATC transport plane illustrated two types of Evans cargo tie-down equipment are in use, as well as one Evans wall-seat for passengers . . . and there is still room to drop the Evans litter-stanchions holding four litters each. This elasticity of use so vitally important to transport planes now in the Armed Services can be developed into a much wider variety of applications for peacetime Air Transport.

SKY PRODUCTS DIVISION

EVANS PRODUCTS COMPANY

DETROIT 27, MICHIGAN

Bearing Down On Friction

Certainty of Action Under Varying Conditions, Plus Savings in Power, are Two of the Ways in which Anti-Friction Bearings Are Making for Faster and More Accurate Production in American Industry. To Gain these Great Advantages, Scrupulous Maintenance is Needed

BALL and roller (anti-friction) bearings are making the modern airplane possible just as in their day they made the bicycle and the automobile possible. Army authorities have said that, without anti-friction bearings, feathering of propellers could not be done, the automatic pilot would be impossible, no man would be strong enough to operate the manual controls of a B-29, and the Norden bombsight could not be aimed accurately.

Many of the advantages of anti-friction bearings lie in their abilities to save power. Airplanes soon to fly will have more than 5000 kilowatts of connected electrical power in them. This means more than the amount connected in an average sized factory; more than enough for a small town. Anti-friction bearings can save up to 90 percent of the power that otherwise would be wasted as bearing friction. Without them the hundreds of motors and controls in a plane would have to be made so much larger and heavier for extra power that the increased weight and space problems would be out of all proportion.

Important as power saving may be, it is not the most important contribution that anti-friction bearings make to airplanes and other machinery. In mounting after mounting the "life and death" factor is the knowledge that "X" amount of power applied to an anti-friction bearing device always will produce "Y" amount of motion or force where it is needed—that the amount of power consumed by the bearings will be the same without regard to load, weather, warming-up period, or anything else.

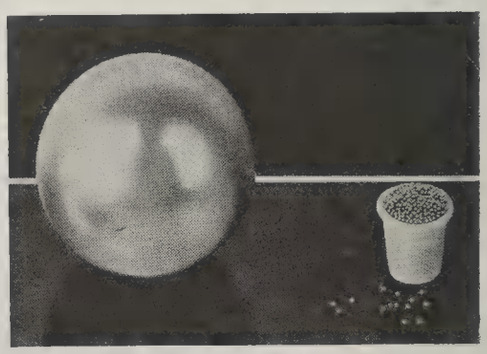


An engineer measures ten millionths of an inch tolerance in a bearing by the use of a microscopic gage of great power designed for this work

Sureness of action under a given force is a way in which anti-friction bearings add to the controllabilities of machines. Sureness of the positions of the shafts or other members carried by the bearings is another. In really accurate anti-friction bearings a shaft will not get out of position because of bearing wear, or changes in the thicknesses of lubricant films, or expansion of the bearings as a result of the heat of running friction. Gears or any other parts which depend upon their accuracies for much of their strengths can be mounted on anti-friction bearings and if placed in accurate alinements they will stay that way.

SCRUPULOUS CARE NEEDED—The trouble is, while anti-friction bearings are saving all this power and adding all this control, they themselves are helpless unless handled with control. They have to be made by the most controlled methods, installed under the most controlled conditions, maintained (when they need any maintenance at all) by men who never grow careless. That is why, after 50 years of use, anti-friction bearings still are only a fraction of all the bearings used. Where they are needed nothing can take their place; where not needed they often are too exacting in the accuracies and other control measures demanded of their users.

Many a machine shop got its first lessons in accurate assembly-line control when it first installed anti-friction bearings in its products. If kept clean and if mounted in highly accurate parts, the anti-friction bearings would perform flawlessly through astonishingly long service lives. If allowed to get dirty or if mounted with shafts and housings that did not match their own high accuracies, they would fail quickly. For all but slow speeds and light loads, therefore, machinery makers learned how to machine and grind accurately and to run dust-free assembly lines—or else they left anti-friction bearings out of their calculations.



The thimble is filled with the tiniest steel balls in the world, measuring .1063 inch in diameter, developed for the Army's Norden bomb sight. The steel in the larger ball would make 156,660 of the smaller bearings

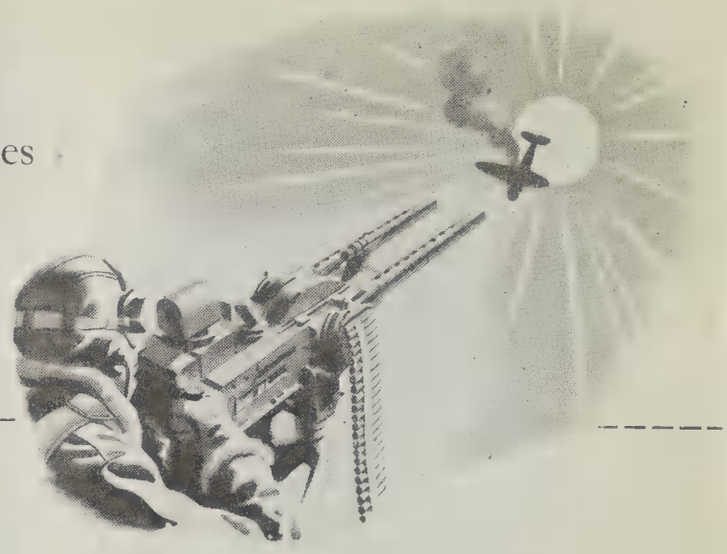
The anti-friction bearings makers learned this same lesson early. Before the turn of this century it was well known that the load- and speed-carrying ability of a ball or roller bearing depends upon control in its making—control of the quality of raw materials, of the accuracies of its parts, of the cleanliness of its assembling and packaging. Inspection operations alone make up more than 50 percent of the costs of manufacturing any good anti-friction bearing.

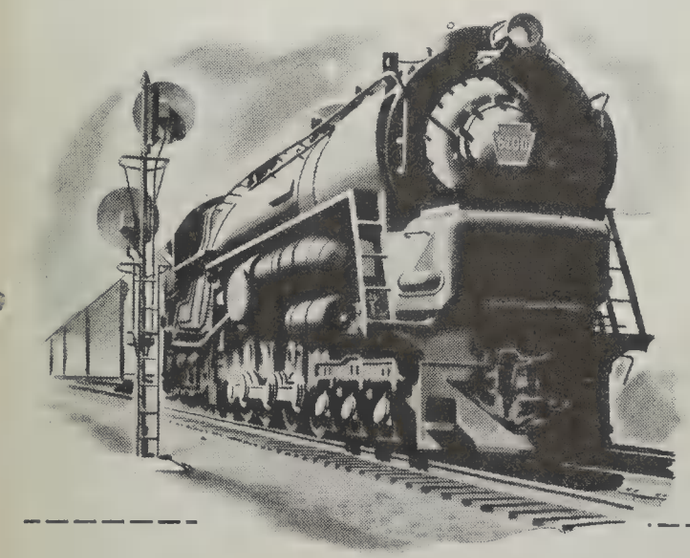
Control brought demands for still higher control. When the machinery makers got used to bearings that would keep heavy loads in accurate alinement on shafts turning at 5000 revolutions per minute, they asked for bearings that would handle heavier loads at 20,000 revolutions per minute. Bearings makers who had been thinking in terms of .0001 inch for both smoothness and accuracies of bearing parts soon had to go to .00001 inch. And so the anti-friction bearings which had been the fathers of accuracy in so many machine shops became the sons of that accuracy in the plants where they were manufactured.

The bearings makers are now working to accuracies—where these accuracies are needed—of ten millionths of an inch as the greatest error permissible on the size of a part and one millionth of an inch on the smooth-

In a bomber a GUNNER uses a new gunsight lamp that permits him to aim *directly into the sun* – blasting enemy planes that otherwise would be invulnerable because of the blinding glare.

. . . the name on the GUNSIGHT LAMP is Westinghouse.





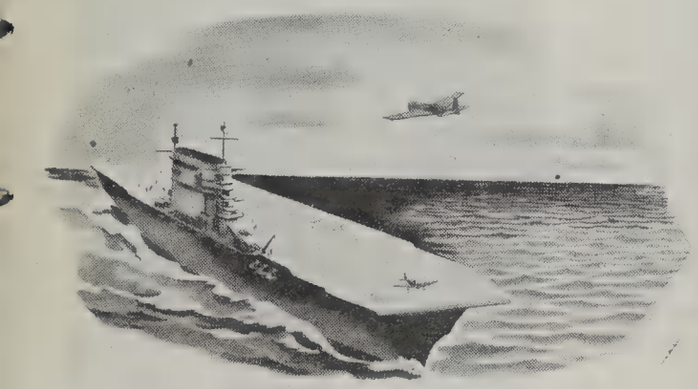
On a railroad an ENGINEER gets smoother operation – and 25% more power – from his steam locomotive because of a revolutionary new steam turbine drive.

. . . the name on the TURBINE DRIVE is Westinghouse.

In an Army arsenal a BALLISTICS EXPERT photographs projectiles, smashing through armor plate, with an x-ray tube that takes a picture in *1/1,000,000th of a second.*

. . . the name on the X-RAY TUBE is Westinghouse.





On a carrier a PLANE DIRECTOR uses a new kind of elevator to hoist planes on deck faster – keeping the deck cleared and getting fighters into the air quicker.

. . . the name on the ELEVATOR is Westinghouse.

Westinghouse

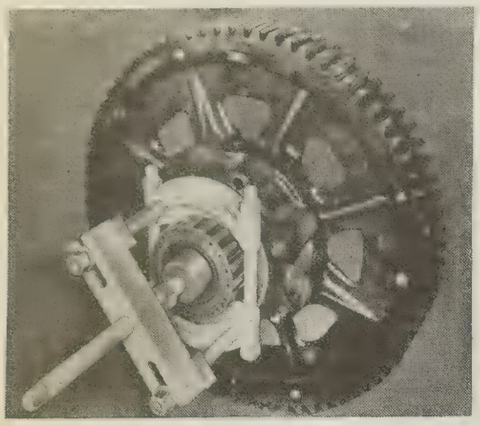
PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY – Westinghouse skill in research and engineering is constantly at work, developing new and better war materials for final Victory.

TOMORROW – This same research and engineering skill will mean more dependable, more efficient industrial equipment and appliances for the home.

Tune in: JOHN CHARLES THOMAS–Sunday 2:30 pm. EWT. NBC

ness. And the end is not in sight. Bearings makers are among the most exacting buyers of steels and other materials—companies like SKF and Timken even make their own steels. Bearings makers are quick to buy any inspection instrument or production machine that will increase accuracy. They will



Maintenance work such as pulling a bearing from a shaft must be carefully controlled and perfectly clean

find out how to turn out better and better products, and with every improvement in anti-friction bearings will come improvements in the controllabilities of many kinds of machines.

Fine electrical instruments are examples of what is going on. The classic type of bearing for these is the hard, smooth jewel. And jewel bearings will continue to be used in millions of instruments. But for the hard shock-load conditions or extremely heavy vibrations of war planes something equally low in the amount of power consumed but far less brittle had to be found.

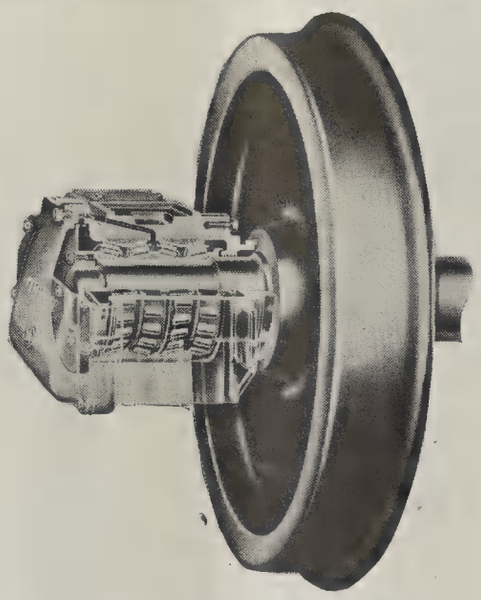
MICROSCOPIC BEARINGS—Special ball bearings filled the bill. They are so tiny that a thimble will hold more than 3000 of the balls which go into them, more than 360 of the completed bearings. Using them, every plane can have row after row of instruments each of which—so far as its bearings are concerned—will perform with complete dependability.

The high production of instrument bearings needed for aircraft means a lot to all other industry. Soon, instruments with these bearings in them will be on looms, on punch presses, in the cabs of locomotives, in all sorts of places where shocks and vibrations had been extremely bad for instruments. The bearings industry knew all along, of course, how to make such tiny bearings, but before the production of planes zoomed as a result of the war, there was no one market with enough demand to pay for learning how to make them at low prices. Now the reasonably priced tiny bearings are here, and they are made to accuracies that make any ordinary "fine watch" look like a lawn mower by comparison. They will be doing things for post-war automobiles, washing machines, and passenger elevators.

Anti-friction bearings are an old story but at the same time an ever new one to the machine-tool industry. Long ago the machine-tool makers started using them to cut down the power demanded. And as machines needed more and more power sources, with sometimes as many as 30 individual electric motors on one machine, the power savings became more and more important. But, as has been the case with so many devices, the certainty of position and of control of parts mounted on them is becoming the real contribution of anti-friction bearings to the metal working arts.

Tungsten carbide tools brought this out many years ago. The speed with which a machine tool does its work often can be multiplied five times or more by the use of tungsten carbide—provided all members of the machine are steady, accurate, and rigid enough to keep fluctuating loads from breaking these tools. Anti-friction bearings, preloaded to take out their initial elasticities, support the spindles with the necessary rigidity.

Even more important, anti-friction bearings permit the electric meters on the machines to tell true stories of how much power is going into the work itself. One of the properties of these bearings is that, clear up to their



Designed especially for railroad use, this Timken bearing fits into existing trucks without requiring change

breaking points, they consume only a little more power under heavy loads than under light ones. Thus when a machine-tool operator glances up at the electric meters on a machine which has anti-friction bearings throughout its power drive he knows that practically all the power registered on those meters is going into the working of the metal. If those meters show too high or too low power readings, he knows that something is wrong and he can shut down his machine or make the necessary adjustments before work is spoiled or harm is done to the tools.

IN STEEL MILLS—Certainty of the amount of power being used at the bearings caused anti-friction bearings to be used in steel and brass rolling mills. With banks of electrical instruments before him, the operator of a mill can tell exactly how much power is being used in work done in the steel itself, can compare this with the temperature of the metal and the exact amount that each pass through each set of rolls is reducing it, and thus know exactly what his machinery is doing. Modern continuous strip mills were impossible before such certainty was obtained. Now, when anti-friction bearings make engineers certain of exactly what positions their rolls will occupy under given amounts of pressure, as well as how much power will be consumed by the bearings, there is no guessing what advances will be made in new accuracies of rolling, new surfaces on steel, new cladding and laminating, new applications of powder metallurgy, and a hundred and one similar improvements.

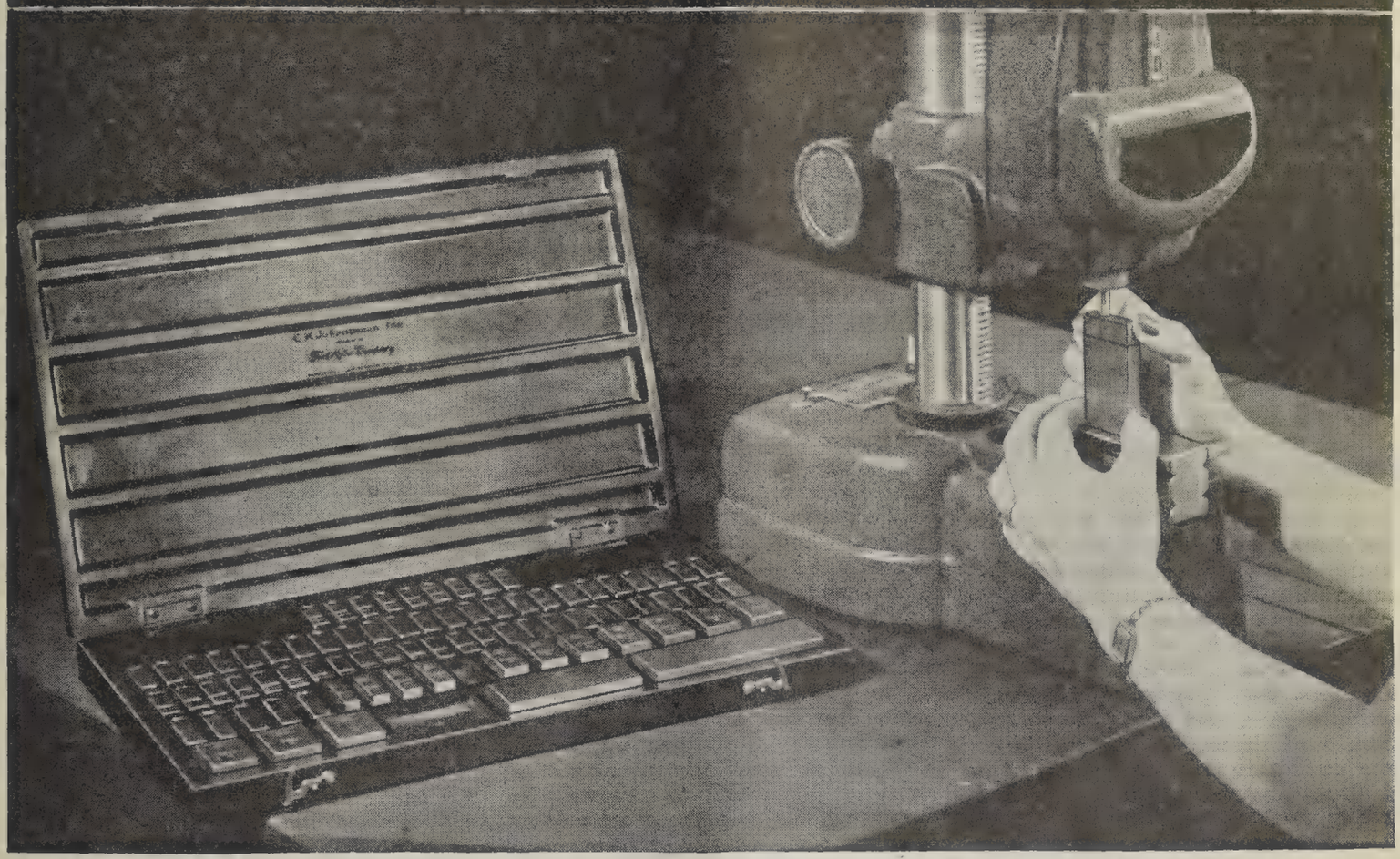
Certainty of the amount of power used is selling anti-friction bearings to the railroads. Power savings are important, of course, but the railroads got along for a hundred years by putting more power in the locomotive to compensate for any extra demand at the car journals. The one thing they could not do without anti-friction bearings was to be sure that no matter how heavy the load in the car, how high the speed, how rapid the acceleration or deceleration, and—within limits—how cold the weather, the power used at the journals would always be nearly the same as well as extremely low. Anti-friction bearing journals start into motion with only about 2 percent more friction than their running frictions, whereas their predecessors need twice as much power to start as to keep going. This means that the anti-friction bearing train has much greater certainty of starting smoothly. It also places much less starting load on the locomotive. And while the anti-friction bearings will not contribute so much to the braking of the train on a down grade, the engineer always knows exactly how much they will contribute and that it will always be the same amount.

This same exactness of operation is putting anti-friction bearings into remote controlled and automatic controlled machines. An operator in a control tower may flip a switch to turn on a pump miles away from him; he has to be sure how much liquid that



A hypodermic syringe is used to put a drop of oil in these tiny bearings. White gloves, gown, and cap worn by the operator safeguard against dirt

Wherever accuracy is important... so is accuracy CONTROL!



● Close-limit machine work calls for inspection standards regularly checked and re-established wherever necessary. Equipment for this kind of gage-testing used to be very costly. But not now. Johansson Gage Blocks are priced as low as $23 a set, with case—$3.50 for single blocks. They come in accuracies of .000004 and .000008. They will put your shop on a basis of enduring accuracy. May we send you a catalog with full details—sizes, accessories, prices? Write today.

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Every shop that works to thousandths or closer — whether on production, adjustments or repairs, needs—

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GAGE BLOCKS and ACCESSORIES

pump will deliver and that this amount is not being changed by variations in the bearing frictions of the pump and its motor. A chemicals process may have hundreds of electrical instruments, each of which is automatically controlling the amounts of power being fed to electric motors; the chemical engineer must be certain that a variation in that power means a similar variation of the work done by the machines and not a variation of the power used by the bearings.

MAINTENANCE PROBLEMS—Such certainty, of course, is not being obtained without a little added trouble. And one of the greatest troubles can be in the maintenance department.

Anti-friction bearings do not always add to maintenance troubles. Many of them have their lubricants sealed in for life; they never have to be oiled and never have to be cleaned as long as the machines they serve last. Many more have so much greater capacities than the loads imposed on them that they will run for years with no more servicing than an occasional addition of clean lubricant.

But when anti-friction bearings do need servicing the maintenance men must pay as much attention to cleanliness and to careful handling as the original installation men—there is none of the carefree abandon with these bearings that so often is found in maintenance departments.

Just as many a machine shop got its first lessons in clean and accurate assembly methods when it first installed anti-friction bearings, many a maintenance shop is being air conditioned so it can keep its windows closed on hot days when it services these bearings. But then, plenty of the highly accurate gears and motors and other devices which use anti-friction bearings need this same cleanliness. And so these bearings, the fathers of control in machine-building methods, are the fathers of control in maintenance.

FLAME SPRAYING

Opens New Engineering Fields for Plastics

THE PROCESS of heating a metal wire in a flame and then, with an air blast, depositing the molten metal on a surface which is to be built up or repaired, has been known since the early 1920's. It was called "metallizing" because nobody ever dreamed that it would be used to apply any other substance than metal.

Now Du Pont announces that polythene, a plastics, can be flame-sprayed like metal.

There is no sign that other plastics makers have paid much attention to such possibilities. But there is no reason why a wide list of thermosetting plastics should not be susceptible to being heated and then sprayed by air blast. The heating temperature does not have to be high enough to melt metal. The plastics does not have to be run directly into flame as is metal. For many a plastics the air for the blast could be preheated to a temperature sufficient to spray the material.

Polythene is an excellent electrical insulator and is tough and resistant to brines, chemicals, and other corrosive agents. It could be flame-sprayed over the contacts of electrical apparatus—the electrician could wire-up his job and then insulate and protect all of the terminals. He could renew damaged insulation while the wiring was "hot" or carrying current.

Plenty of heat spraying of plastics could be done to provide finishes, fill up worn spots, provide special protection against weather or corrosives, and so on.

But one thing is sure. If very many plastics are applied by this method, then a new name or a series of names will have to be coined. "Heat-spraying" could be used as a generic term for the whole process, with "metallizing" remaining for the application of metals and "flame-spraying" applied to anything which is melted directly by the flame.

TORQUEMETER

May be Applied to Obtain Greater Machine Efficiency

MACHINE tools and all kinds of process equipment for paper mills, chemical plants, and oil refineries moved one step farther toward perfection of control when Westinghouse Electric and Manufacturing Company developed its magnetic-coupled torquemeter.

Originally worked out for aircraft engines, this instrument measures the minute amount of twist which occurs in the steel shaft that connects the engine to the propeller. Since the exact amount of twisting which that shaft will do under any given twisting stress or "torque" is known, by measuring this twist the exact amount of power being delivered by the engine also is known.

It is important to machine operators to know the amounts of force being delivered to cutting tools, mixing paddles, and other devices. In machine tools that force is a measure of the kind of work being done on the materials being fabricated. In papers, chemicals, and the like, that same force determines the work done on the materials by the process, and this in turn affects the qualities and properties of the finished products.

The ordinary way to measure the amount of work being done is to read electric meters attached to the motors which drive the machine. But these meters can tell only the total amounts of power that the motors are delivering. Between the motors and the points of work may be shafts, bearings, gears, and other devices, each of which can consume varying amounts of power under varying temperatures, amounts of wear, and other conditions.

The torquemeter would be attached to the final drive shaft as close to the actual point of work as possible. Its invisible magnetic "fingers" in the form of air gaps would pick up variations in the amounts of twist imparted to the shaft and convey these variations to instrument boards or to automatic controls.

Right now the principal use of the torquemeter is to enable the airplane pilot to adjust his engine speed, propeller pitch, and carburetor pressure to get more mileage from each gallon of gas. But, with time, the refinements in the production of aircraft components resulting from the use of these torquemeters in the plants which make parts for planes will result in far greater flight economies.

V-DAY PROBLEM

Raised by Instructions For Storing War Equipment

MANUFACTURERS who have large plants crammed with government-owned machinery and who expect to move this out and put in their own machines at war's end, are staring gloomily at government regulations for the care of the war equipment. The government does not intend that its property shall suffer between shutdown and resale, but expresses little concern about who will perform the labor and pay the bills for protecting it.

Trouble will be plentiful. According to government order P.S. 300-4, if machines are to be stored for more than 90 days in open or closed storage, somebody has to:

Remove all removeable accessories, apply one protection to non-critical surfaces and another to highly finished ones.

Wrap loose parts as prescribed; pack them in boxes which shall be attached to the machine skids.

Drain lubricant systems, clean them, refill with AXS-Grade 2 or with AXS-934 Grade 1 or USA 2-120 protective compounds, depending on whether they originally contained SAE 30, SAE 10, or light spindle oils respectively.

Clean coolant system with fresh coolant, refill with AXS-674 or AXS-394, putting in enough so lubricant can be circulated through entire system. Operate machine under no load long enough to coat entire system. Drain. Save the excess oil or use it for protecting another machine.

Remove grease from internal gears and replace with clean lubricant. Take the oil out of oil-lubricated journal boxes and refill with AXS-934 Grade 1 or 2 as required.

Drain hydraulic systems, refill with AXS-934 Grade 1, operate machine enough to wet all surfaces. Manually remove gums and sludges.

Clean external surfaces with solvent. If they rust, clean again with solvent mixed with protective compound. Then coat 3/64 inch thick with USA 2-121 or USA 2-82 heated and sprayed on.

Follow minute directions for sealing openings, vents, or louvers. Wrap according to exacting specifications. Skid. Then find a place to put the machine while the company's own equipment is moved into the shop.

It looks as if there would be plenty of work for returning service men!

Plastics Aloft

From Practice Bullets to Helicopter Parts, From Structural Materials to Electrical Insulators, Many Kinds of Plastics Are Essential to Aviation Today and Tomorrow. They are Both Utilitarian and Decorative

PERHAPS the most unusual plastics application to be made public recently is the frangible bullet which sluffs away to powder upon contact with the target. Molded of plastics and lead, these bullets are now being used in training Air Force gunners and may in the future serve as practice ammunition for sections of our armed forces.

Until the development of these frangible bullets by the Army Air Forces—in co-operation with the National Defense Research Council; Dr. Paul Gross, Director of Research of Duke University; and research chemists of the Bakelite Corporation—gunners went into battle with a distinct handicap. Whereas navigators, pilots, radio men, and even bombardiers could duplicate in training the performance expected of them over enemy territory, there was no way in which a gunner could safely fire a live bullet at a real plane flown by a live pilot. The best he could do was shoot at targets towed through the sky by a fellow flier.

Now, as a result of the perseverance of Major Cameron Fairchild, who conceived the idea of these frangible bullets, gunners can not only aim but fire at real planes and have the additional benefit of knowing whether or not they were on the target. Early experimental work on the bullet was carried out with a pellet of tempered glass in which the molecular cohesion is such that it disintegrates into a fine powder when the sensitive tip is shattered. The glass bullet proved too costly, however, and the research workers turned to a lead and plastic compound which was found to be hard enough to go through the mechanism of a 30-caliber machine gun, yet fragile enough to crumble into fine powder upon impact with the specially treated duralumin armor employed on the target plane.

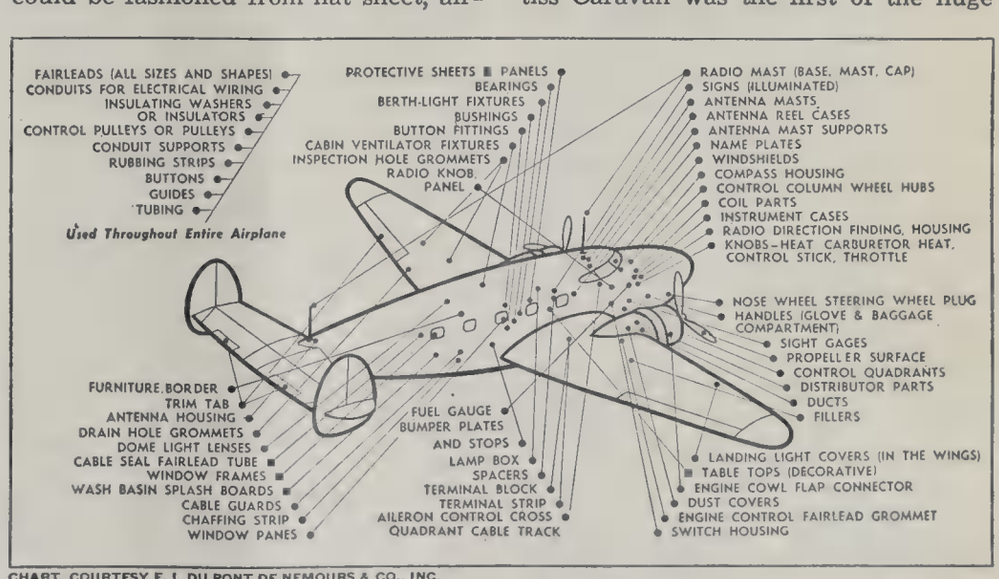
TAKING THEM UP—While this success of plastics in helping to bring down enemy planes is of recent origin, the work which these materials have been doing to get our planes into the air and keep them there dates back to the early days of flying. When search was being made for materials to replace the stick-and-fabric construction of the Wright brothers, one of the first materials tried for wings was a form of plywood. In fact, plywood as a structural element of the fighting plane is a veteran of World War I. The famed crates that reconnoitered over the German lines and fought it out with von Richthofen's Flying Circus relied on glued plywood and fabric.

However, these early laminated woods and plywoods, which used albumin and casein cold-set glues, were susceptible to warpage and fungus growth. When the civilian aircraft industry swung completely over to the all-metal plane, following the success of the Ford tri-motor, the United States armed forces went along, and until the metal shortage became critical with America's entry into World War II, little attention was paid to wood construction.

The early plywood planes had another disadvantage. The veneers were first glued together in a flat press. Then the sheets were wet or steamed and sprung into form. This type of construction had limitations. When the flat-pressed veneers were bent to compound curves they tended to return to their pressed condition, wrinkling and changing shape. These objections to wood construction were, for the most part, removed in the 1930's with the advent of improved hot-press equipment and the commercial availability of thermosetting resin adhesives in both film and liquid form. In fact, after improved forming techniques had been developed in response to a demand for more complicated shapes than could be fashioned from flat sheet, aircraft plywood enjoyed a number of advantages over the lighter metals. Its weight-strength ratio is favorable, and its stiffness outstanding. (The EI, or stiffness value of aluminum is 22; that of birch plywood is 178 and of spruce plywood 416.) In addition, plywood can be molded easily and cheaply into monocoque shapes of extreme complexity, whereas metal fabrication is both more difficult and more costly.

PLASTICS PLANES—In 1938, attention was focused briefly on the aircraft possibilities in the newer molded plywoods when Clark Aircraft Company brought out an experimental plane with a plywood fuselage which had been molded complete in two hours. Representatives from the Army Air Forces who observed the tests of this plane conceded the practicability of plywood parts for light trainer planes but could see little possibilities for the use of the material in combat service. Then came the war. The cry was for planes and more planes, all types of planes.

Among the planes that have rolled from the production lines since the outbreak of hostilities, the Mosquito is noteworthy because it is the first Allied bomber to take advantage of the structural and aerodynamic qualities of resin-bonded plywood. And the Curtiss Caravan was the first of the huge



CHART, COURTESY E. I. DU PONT DE NEMOURS & CO., INC.

No single aircraft employs all the plastics items shown on this chart, but all of these and many more are in use today on passenger, freight, and fighting aircraft

cargo planes to be similarly constructed. To this list can be added trainers and gliders, turned out in swarms to meet the needs of an expanding air program.

Still in the experimental stage is the use of glass cloth laminates as structural materials in our planes. Use of plastics laminates had previously been restricted to non-structural parts such as fairings, fillets, and door, because physical properties were not adequate for primary structures. Developments in the use of high-strength fibers in combination with synthetic resins, however, appeared to open an entirely new field for laminates having adequate strength for primary structures.

From among many different types of fibers, glass fibers were selected as the reinforcing agent because of a strength-weight ratio substantially greater than that of the other materials. Furthermore, glass fiber manufacture can be closely controlled, making possible a uniform laminate. The development of no-pressure, low-temperature thermosetting resins to take the place of high-pressure-type laminating resins which had proved impractical, overcame the final obstacle to the production of plastics laminates possessing adequate strength properties, low moisture absorption, weather resistance, and dimensional stability.

TRANSPARENT ENCLOSURES—Important as is the use of laminated wood and plywood and glass cloth laminates for the structural elements of a plane, these applications represent but a fraction of the service plastics are rendering to the aircraft industry. It is estimated that there is an average of 200 plastics parts in today's fighting ships of the air. Many of these applications are indicated in the accompanying drawing. Although no one plane may have all these parts, all of them—and many others—are essential elements in present-day passenger, freight, or fighting aircraft.

A wealth of transparent enclosures characterizes the modern warplane. Nose sections, cockpit enclosures, gun turrets, observation hatches, blisters, windows, tail empennages—any place in the plane where it is necessary for a man to have clear and unobstructed vision of sky or ground—all are fabricated of acrylic or cellulose acetate sheets. These plastics sections are favored not alone for their optical properties but because they possess other qualities which make them eminently serviceable. They weigh less than half as much as glass, yet are strong enough to withstand the wind pressure encountered by planes travelling at 300 or 400 miles an hour. Their extreme ease of forming is another factor in their favor.

One of the latest developments in this type of application is a shatter-resistant plastics glazing capable of resisting shock-impacts, such as the effects of penetration by machine-gun and cannon fire, or gun-fire concussion. The need for such a material grew out of the increasing use of pressurized cabins in war planes which are often called upon to operate at high altitudes, many in excess of 35,000 feet. Under conditions of pressurized flight the transparent sections are under high stress. Because of this condition there was the constant danger of the glazing shattering if penetrated by enemy gunfire.

In the absence of a material capable of resisting penetration of gunfire, the next best alternative was one in which bullets make holes of minimum diameter and which has a limited fracture area. Under these conditions the hole may be quickly closed with a temporary transparent patch. The solution proved to be a laminate made up of two layers of methyl methacrylate resin with a layer of polyvinyl butyral resin between them.

NON-STRUCTURAL APPLICATIONS—A variety of plastics materials—molded or laminated plywood, veneer, and cotton fiber impregnated with phenolic resins, among others—have been employed for such non-structural airplane parts as elevators, flaps, ailerons, stabilizers, vertical fins, rudders, tabs, and controls. And then there are the ammunition chutes, ejection hoppers, ammunition boxes, cable guards, and fairings formed from such materials as phenolic canvas-base laminate. There are a number of advantages to the production of these last named parts from plastics rather than metal. The use of laminated phenolic effects a saving in time as compared to that required for the forming of metal, reduces cost, and lessens weight. In addition, plastics fairings have less drag since there is not the surface unevenness which riveted metal parts possess.

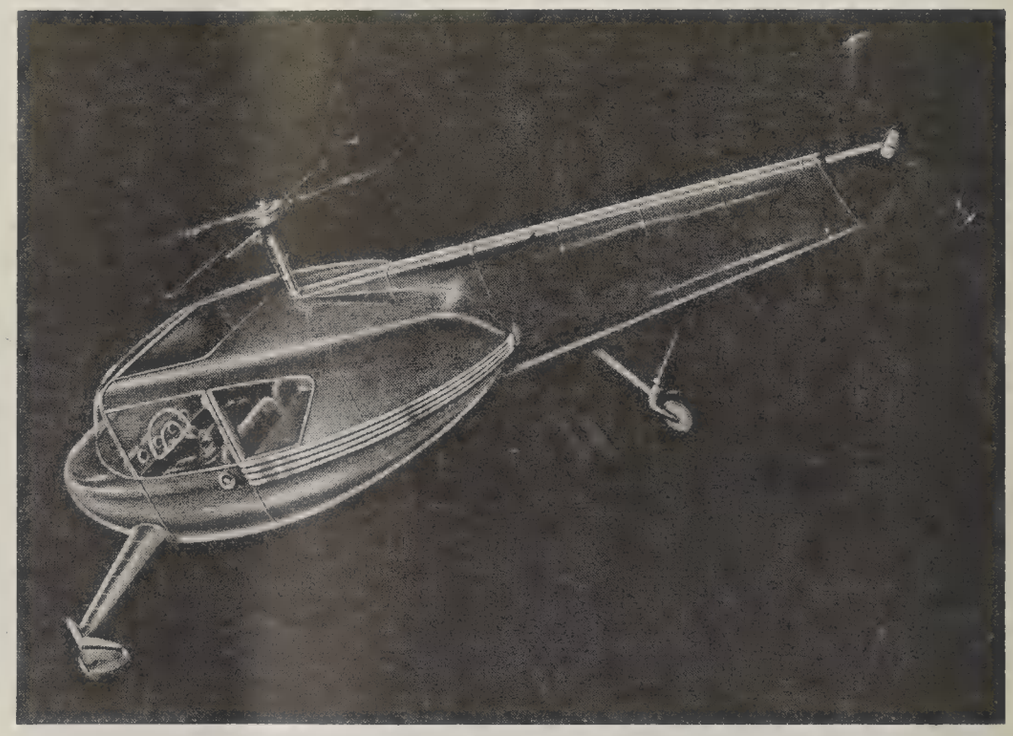
A fighting plane without its radio operates under a severe handicap. In this all-important unit of combat equipment, the superior strength, impact resistance, and electrical properties of plastics have been drawn upon by designers of modern planes. The entire radio circuit is studded with molded phenolic plastics as are those of the lighting, control, inter-communication, and motor systems. Circuit breakers, switch boxes, toggle switches, panel boards, sockets, connectors, terminal blocks, switch box covers, meter boxes, terminal boxes, junction boxes—all take advantage of the excellent electrical qualities of this plastics material.

For night flying when the plane's lights must be extinguished, illumination of instrument panels, switches, nameplates, dials, and charts is made possible by laminated plastics with wiped-in fluorescent markings or by fluorescent plastics sheeting.

LOOKING AHEAD—With the war still to be won it is difficult to give any detailed information of the exact part which plastics will play in post-war aviation. Generally speaking, however, we can expect the future commercial cargo aircraft to utilize the light weight, production speed, high strength, and electrical characteristics of plastics in many functional parts. For civilian aircraft will be added low cost, color possibilities, and design for eye appeal.

Helicopters, because of their ability to hover over a given point, land on terrain not easily accessible by present transportation standards, and to rise and descend vertically should, in the future, prove valuable for many commercial purposes. However, before any volume in helicopter sales is reached, the manufacturers have three problems to solve. They must make these planes safe to operate. They must make them easy to operate. And they must make them economical to operate.

It is possible that the fuselage of the post-war helicopter, in addition to being constructed of light metals, will feature low-pressure laminates produced from low- or contact-pressure resins reinforced with glass-fiber fabric or other materials. The transparent portion of the planes' bodies will be even more extensive users of plastics. The metal parts that will be employed in helicopter construction will require a protective coating against corrosion and the elements. Even before in-



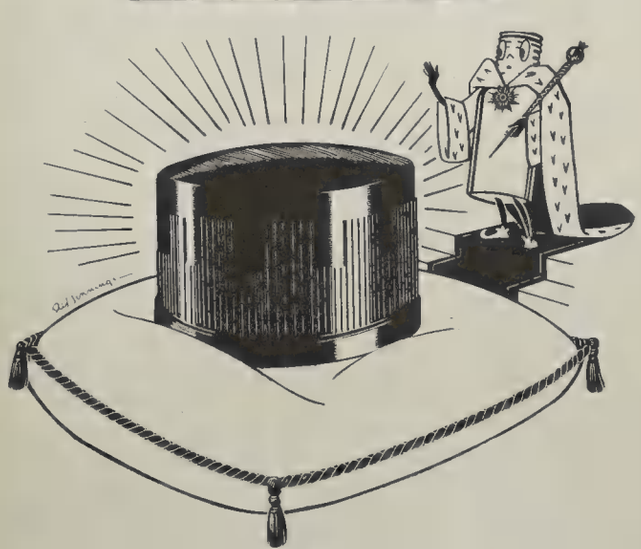
Post-war helicopter design as envisaged by Dohner and Lippincott

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

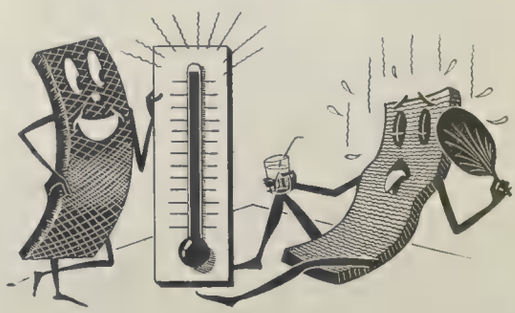
MOLDING COMPOUNDS



TOPS IN TOPS

There's a good reason why more closures have been made from Durez than from any other plastic material. In a nutshell, it's because of the unusual versatility of Durez phenolic molding compounds. Such properties as non-bleeding, eye-appealing finish, excellent moldability, and resistance to moisture, chemicals, alkalies, and temperature extremes make Durez phenolics the ideal material for manufacturing closures of all sizes and shapes . . . for all purposes. These same versatile properties also account for the extensive use of Durez phenolics throughout practically all fields of industry where the miraculous progress of wartime research has made their applications almost limitless. To the progressive manufacturer who is thinking ahead . . . planning to market his new products during the post-victory era . . . Durez offers a line of more than 300 versatile phenolic molding compounds from which to select the plastics that fit the job.

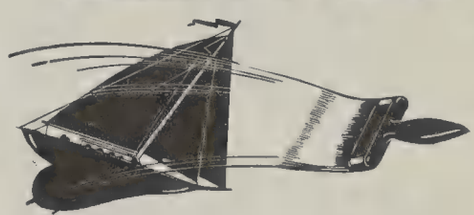
INDUSTRIAL RESINS



BREAKING A BRAKING PROBLEM

To be good, a brake lining must possess two qualities to the utmost degree . . . heat resistance and durability. Asbestos fiber bonded with Durez phenolic resin has proved a tremendously successful formula for brake linings because it inexpensively combines the natural heat resistance of asbestos with the durable toughness and heat resistance of Durez resin to form a finished product that meets the highest standards. The wide range of properties inherent in all Durez phenolic resins renders them invaluable to the imaginative design engineer who is in search of a bonding or impregnating resin that is really versatile.

OIL SOLUBLE RESINS

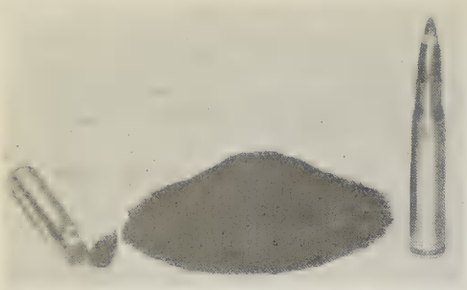


IMPREGNABLE COAT FOR A SEA-GOING BOAT

Such properties as durability, excellent finish, and resistance to marine growth, fresh water, salt water, gasoline, and oil which Durez resins impart to marine paints and varnishes, have made these resins invaluable in producing boot topping, topside, and bright-work finishes for boats of all types. The tremendous progress which Durez laboratory technicians have made in developing resins for protective coatings of every description is reflected in their wide wartime use . . . and in a myriad of new applications designed for post-victory markets.

The past four years of wartime urgencies have advanced plastics' progress by a decade. Many new and unusual applications . . . applications for which plastics have proved better suited than any other material . . . have been developed. The twenty-five years' experience of Durez technicians combined with the natural versatility of Durez phenolics proved invaluable in aiding the successful development of many of these applications. As specialists in the production of these most-versatile-of-all-plastics, Durez' background includes actual working experience in practically all fields of industry. The benefits of this background and the enormous collection of data in our files are available at all times towards helping you select the proper plastic material to fit your job. Durez Plastics & Chemicals, Inc., 526 Walck Road, North Tonawanda. N. Y.

PLASTICS THAT FIT THE JOB



A frangible bullet on the right; on the left, a slug that has been broken to show texture. The pile of powder in the middle was obtained by firing a number of frangible bullets against a target of tough duralumin

corporation in the plane these metals may be well protected by plastics. When metal parts are stamped out, oil and grease are forced into the raw metal to reduce heat and friction. In order to restore the original condition of the metal, the surface must be cleaned prior to assembly. However, it has been found that pre-treatment of the metal with plastics before the stamping operation eliminates these cleaning operations and is faster, cheaper, and more efficient. Vinyl copolymer resins are applied as a coating which is then baked at approximately 300 degrees, Fahrenheit. These resins cling well to the metals to form a protective, flexible coating and, regardless of what happens to the metal during stamping, the coating maintains a continuous protective flexible film.

It is safe to say that the three factors upon which helicopter sales post-war must be predicated—safety, easy operation, and low cost—will be solved. Helicopters will not replace the plane or automobile, they will not be made predominantly of plastics, but they will make good use of these materials and their sales will run into many millions of dollars.

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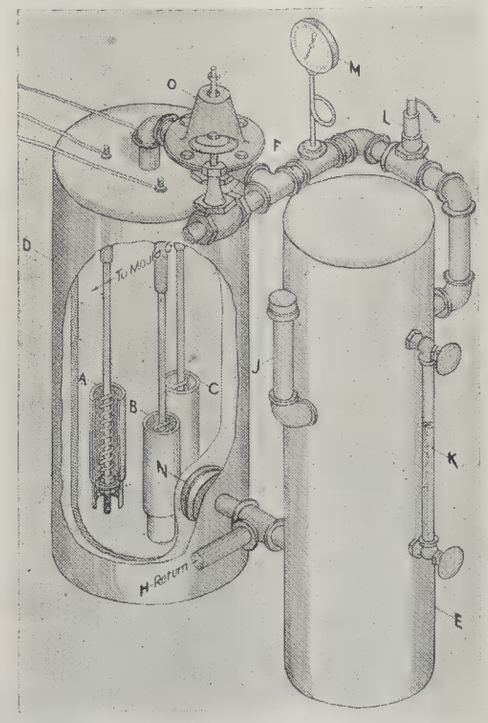
STEAM GENERATOR

Saves Power Costs in Plastics Molding

COMPRESSION molding of plastics gives indications of being strongly influenced by a radical electric steam generator designed for use on individual presses and intended to take the place of a central boiler.

This steam-generator unit was developed by the Vaportron Corporation in co-operation with a number of molders who installed the early models in their plants for testing purposes. Basically the operation of the system is as follows: Water in the steam-generating tank D completes the circuit between the three electrodes A, B, and C, causing a certain amount of current to flow in the system. A maximum flow of current will take place when the electrodes are completely covered but there will be no flow at all when the water level is below the bottom of the electrodes. Passage of current between the electrodes heats the water to the boiling point. The resulting steam passes through a pressure regulator O, and through steam lines which lead to the pressure tank E and to the feed line to the mold platens G. The return line H is used to collect the condensate from the mold and return it to the boiler.

Generating steam in a closed system causes the pressure to rise. When it rises enough to lift the diaphragm valve, the flow of steam is shut off. With the steam supply blocked by the regulator valve O, the pressure in tank E drops until it is less than that in the generating tank D. The higher pressure in D as compared with E causes the water level to drop in D by reason of the fact that pressure in D forces the water out through the lower feed



Drawing of the new steam generator designed for use on plastics presses

pipe into the tank E. This action equalizes the pressure in the two tanks.

However, at the same time, the water in the steam generating tank D has dropped to a lower level on the electrodes, reducing the amount of current flowing through the water and, in consequence, the amount of steam that is generated. This sequence of events causes the steam pressure in D to drop still further until it reaches a point at which the regulator valve reopens and allows steam to flow once more through the valve to the mold and to the pressure tank E. This comparative reduction in pressure permits the water to rise on the electrodes so that the amount of current passing through the water is once more increased and the steam pressure again begins to rise. In actual practice, the pressure in the feed line to the mold remains practically steady while the amount of current drawn by this unit fluctuates according to the actual steam demand.

When the final model of this steam-generator unit was tested on a 150-ton press, the average power consumption for the press was seven kilowatts per hour. At an average cost of one cent per kilowatt hour, the cost of power to generate the steam for the 150-ton press was in the neighborhood of seven cents per hour.

It is estimated that a standard boiler installation on a 150-ton press would consume 60 pounds of steam per hour. On the basis of figures supplied by one large utility it is estimated the cost of this steam would be 7½ cents per hour. In addition to power savings, there is the advantage of increased efficiency which is attributed to the use of these new steam units.

OFFICE FURNISHINGS

Employ Many Types of Functional Plastics

AIRCRAFT companies have been among the first to realize that the essence of comfort and convenience lies in the elimination of unnecessary detail. In their application of this belief to the furnishings of offices and terminals, the United Air Lines now employs many types of functional and decorative plastics materials. Examples include Rocoteen for counter facings, Marlite for ticket counter tops, and transparent covers for tops of tables and counters so that time tables and other printed matter can be placed underneath for ready reference.

Inexpensive chromium-gray pyroxylin-coated fabric which replaces the conventional polished walnut is impervious to scratch and cleans easily. The material is reinforced by padding to absorb shock and is held in place by chromium upholstery nails. The Marlite covers on the ticket counters have the advantage of being cigarette proof and stain resistant. Both color and pattern are impregnated in the material, which requires neither waxing nor polishing.

PLUMBING FIXTURES

Can Make Good Use of Plastics

SEVERAL interesting designs for post-war "Dial-Ese" bathroom and kitchen faucets have been worked out by Henry Dreyfuss for the Crane Company. This proposed line uses a plastic dial-type handle on the faucet instead of the conventional pre-war handle. Its operation is based on a new principle which makes it possible for the water to be turned on and off with the same ease that is experienced when a radio or inter-office communication system is shut off or turned on. The new type of faucet is reported to be equally adaptable for use on the kitchen sink, the bathroom lavatory, the bathtub, or the shower.

Plastics may have many more uses in plumbing fixtures. Nozzles of dish-sprays may be of plastics. Or mixing-spout faucet and drain connections may be mounted on a non-staining easy-to-clean plastics panel. But, in all applications, careful consideration should be given to the properties of the material to be used, from the inception of the design to final production.

Motor Vehicles Post-War

Will Aircraft Manufacturers Invade the Automotive Field? Will Motor-Car Makers Produce Airplanes? Where Will the Parts Manufacturers Fit Into the Picture? Investors and Technicians Alike Want Answers to these Questions, Based on Logic and Established Fact and Experience

DESPITE trends in global military operations, highway transportation in the United States is bound to face harder going before things change for the better for either operators of motor-vehicle fleets or small business men, each with his single truck, bus, or taxicab.

One important segment of the nation's major economic dislocation because of the war has been the violent upset of the vast manufacturing facilities that comprise the automotive industry. No matter when V-E or V-J day may come, the whole automotive industry faces a long period of readjustment and retooling. The problem is basically one of production engineering, but the program probably will be confused by the continuation of Government controls by bureaus and agencies which have set their caps for maintaining their regulatory functions.

Even were the nation not suffering from the philosophy of Government in business, the reconversion of the automotive industry from weapon manufacturing back to peace-time products would be an involved affair. Some 5000 manufacturing companies—many of them small, some of them huge—constitute the automotive industry. A part of these companies sell only a small part of their product to the industry; others sell their entire output to vehicle manufacturers, directly or indirectly.

No one vehicle builder manufactures the whole car, truck, or bus. Some manufacture more of the component parts than do those few companies which are, in effect, designers, assemblers, and distributors of their vehicles. As a result, Chevrolets, Fords, or Plymouths, for example, are in part actually manufactured by thousands of materials and parts suppliers.

MACHINE TOOLS—Preliminary investigation of the machine-tool requirements indicate that between 4000 and 5000 machine tools will be needed to get the pre-Pearl Harbor model cars back into production. Many of the required pieces of manufacturing equipment will take from seven to nine months to build, and our military needs and commitments to Russia and Great Britain have many of the machine-tool building plants jammed with orders. The rehabilitation of the occupied countries of Europe and Asia will require many more machines of the American builders.

A change in existing priorities can help to prevent serious unemployment. Until these thousands of parts plants can get new machinery installed, and until the motor-vehicle plants themselves are supplied with needed tools, production of new cars, trucks, and buses cannot begin.

A large number of cars, trucks, buses, and taxicabs are standing idle today because of the lack of parts for repairs. The Army, for example, has purchased a huge supply of parts for their vehicles. Reason for this apparent over-buying was that the military leaders wanted *all* of their supply depots stocked—not knowing where or when the lightning of combat requirements was going to strike next. The Army and Navy have begun to channel back to the civilian a great deal of surplus material, but the process will be slow.

The Government has a conglomeration of parts produced by vehicle manufacturers and parts makers, plus some slightly used parts, all of which would have to be sorted and segregated to get back to the right car dealers, garages, and fleet owners. Vehicle companies are buying back parts in their original packaging, in some instances, but the process of segregation is slow because of the large number of depots and the few people available for sorting.

A recent survey of opinion among automotive engineers indicates that little of the design advancements developed during the war, or the manufacturing efficiencies developed by the far-flung "arsenal of the democracies," can be transformed into post-war vehicles very rapidly. The fastest way to get vehicles built for civilians after the war would be to modify the pre-war vehicles as little as possible, and to go back to the manufacturing techniques successfully used before the war.

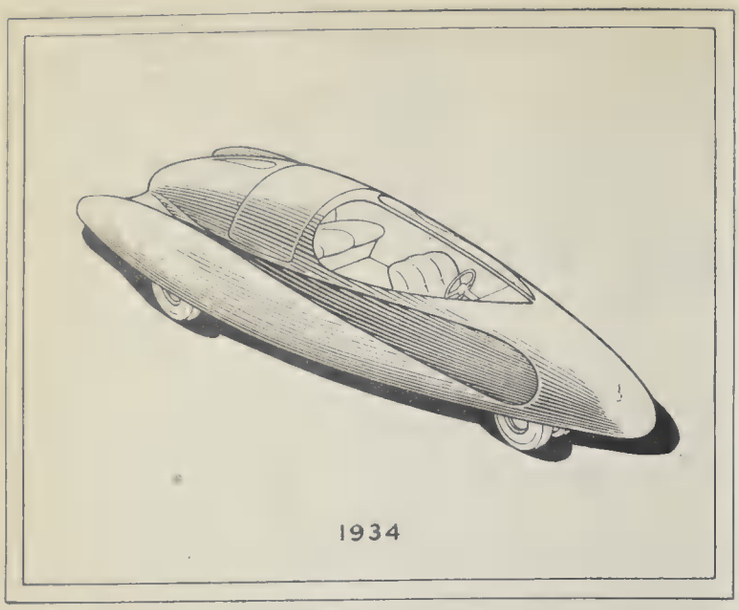
IDEAS DIFFER—Vehicle engineers have investigated aircraft designs carefully to see what ideas could be borrowed. The search has been rather fruitless. Many of these vehicle engineers have been working on the production of aircraft, aircraft engines, and aircraft accessories during the war, but find that the aircraft point of view is not compatible with their own.

For example, in the design of variable-pitch propellers—which might be considered a transmission—provision is made to keep the lubricant flowing through the gears by pumps, and the oil is constantly cleaned. In aircraft-engineering thinking this is necessary to prevent failures and yet permit the lightest possible weight. Failure is prevented in vehicle transmission design by disregarding the weight, making the parts sufficiently sturdy by ample use of material, and flooding the transmission case with lubricant. There it churns until renewed, oblivious, as it rolls along the highway, to stratospheric temperatures and variations in atmospheric pressures alike.

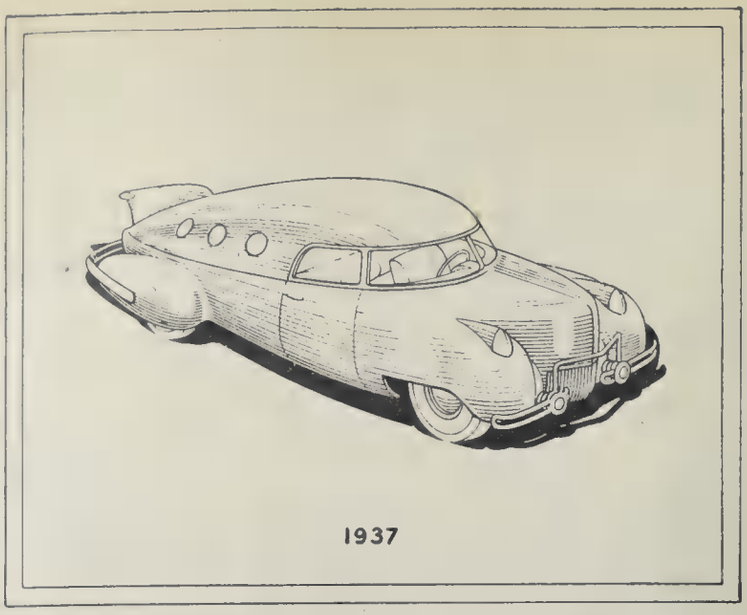
Vehicle engineers liken an aircraft engine to a piece of jewelry because every ounce of weight that can be removed—consistent with the factor of safety—is machined off. Every engine part is designed to take as much stress as possible for the least possible amount of weight of the part. In a car, truck, bus, or taxicab, a few pounds of weight here and there is of no consequence. The result is that an airplane engine cost about $10 per horsepower just prior to the war, whereas the mass-produced car engines cost nearer $1 per horsepower.

Automobile engineers who have been building aircraft engines, which were designed and developed by aircraft engine manufacturers of long experience, marvelled at the Army and Navy requirements for engine testing. This is a complicated task, requiring tear-down and rebuilding, a practice known in the vehicle industry only during the process of developing a new engine. This accounts for most of the high cost-per-horsepower, but the Army and Navy insists that it is one of the reasons our engines are as dependable as they are on all combat missions, in all kinds of weather, and in all sorts of fighting maneuvers.

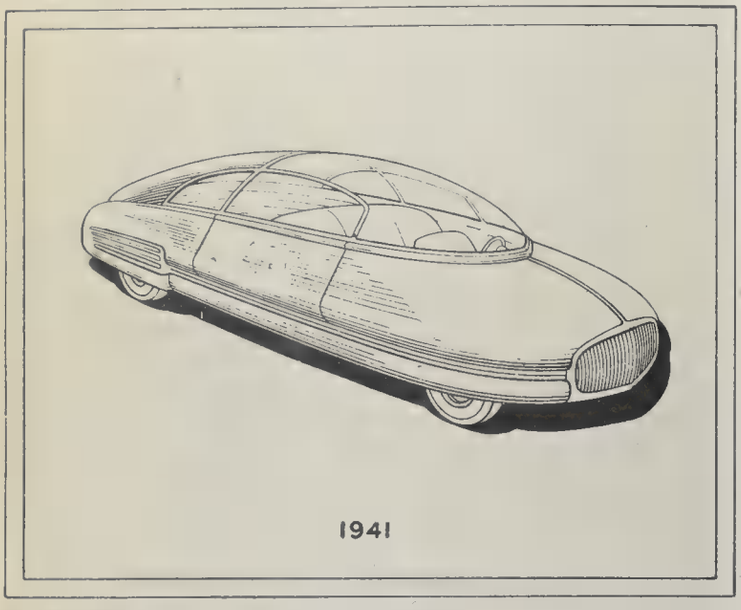
To achieve the remarkable performance of American aircraft engines, a myriad of minute details have had serious study by design engineers. Each manufacturing operation is carefully supervised, and constant inspection i



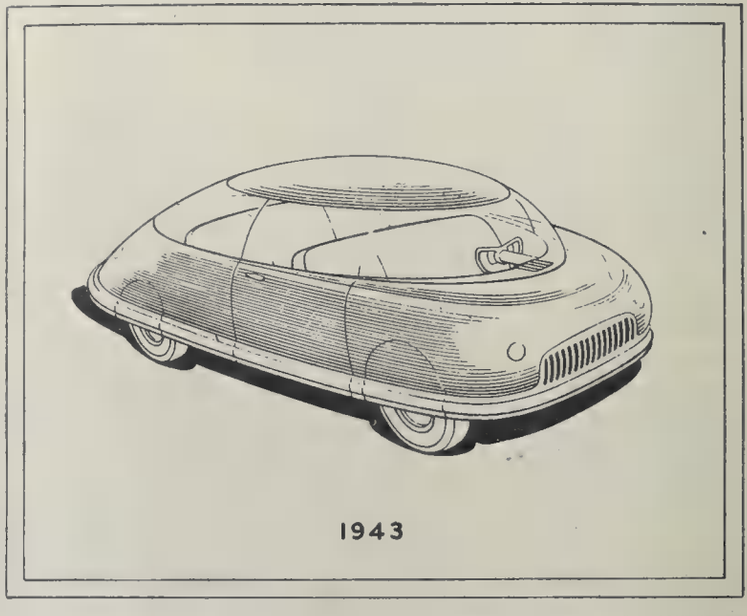
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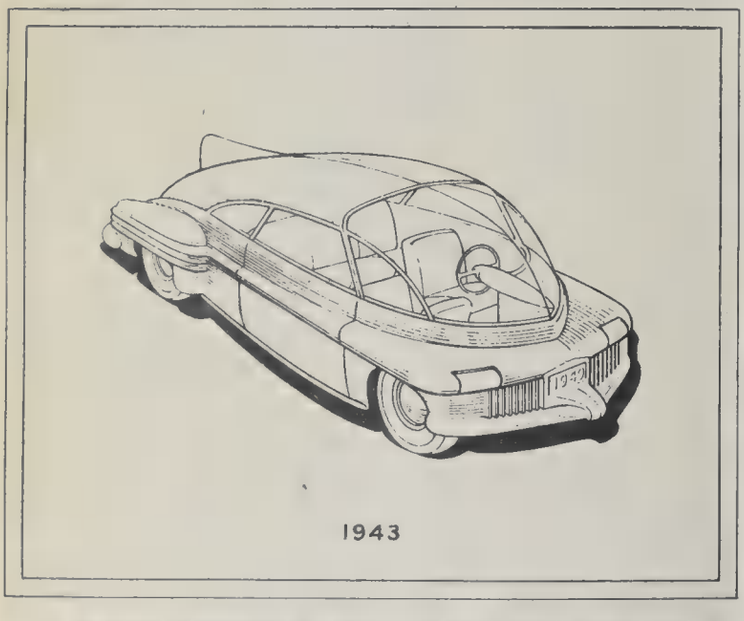
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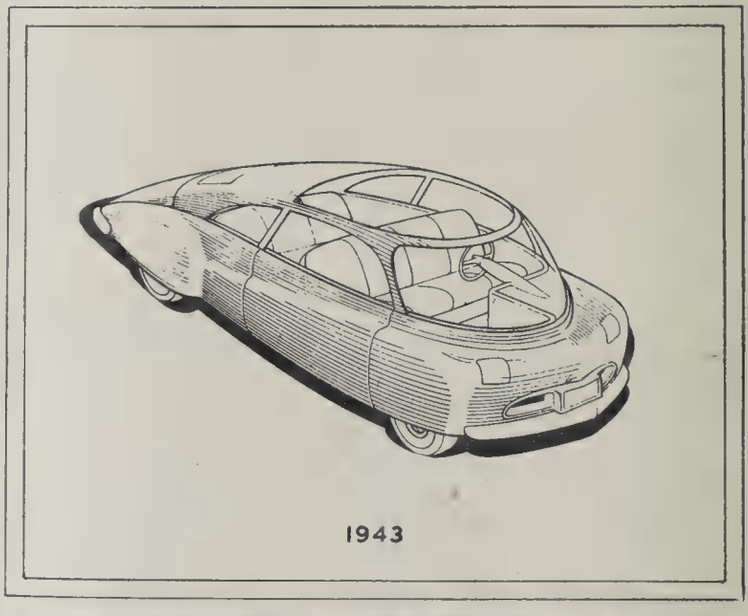
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1943



1943



1943

A group of sketches of "the car of the future" dating back as far as 1934. It is not uncommon (and this is just as true today as in the past) for engineers to whom such sketches are submitted for consideration to criticise rather than praise. The basic trouble is that artists, striving for effect, are inclined to overlook comfort, leg room, and space for component mechanisms

the inviolate rule. This same costly manufacturing procedure goes on in airframe, wheel, brake, propeller, and other component and accessory manufacturing plants from coast to coast.

The motor vehicle, on the other hand, has been in production many years, and the basic engineering design changes from year to year are relatively few, as compared with transport and particularly with combat aircraft. Thus, similar testing and service experience has been obtained, but over a long period of time and without the excessive premium of cost required in war-necessitated speeding up of airplane manufacture.

AIRCRAFT TO AUTOS—When vehicle production engineers are asked if they fear the "encroachment" of aircraft manufacturers into their field, they usually smile and recount some of the costly steps taken in aeronautical development and manufacture. "They won't stay long unless they learn how to cut manufacturing dollars into pennies," is an expression typical of a number of responses.

However, many of them agree that armament development and manufacture, as well as accelerated aircraft production, has taught many lessons

which will later be used in American industry.

Specifically, the Ford Motor Company has announced that it will retire from the aircraft and aircraft engine manufacturing business at war's end. It will be recalled that this company pioneered the mass-production idea in aircraft manufacture with the Ford tri-motor, all-metal airplane, many of which are still carrying passengers and freight in South America.

On the other hand, another veteran automobile manufacturing concern, the Packard Motor Car Company, plans to go into the aircraft and marine business, as well as to continue to make cars in the post-war era. Thus the answer to the question that has investors and prospective consumers in a dither is "no and yes." Certainly, if the post-war airplane market is a profitable one, a large number of vehicle accessory companies will participate.

Vehicle engineers discount the aircraft type of engine for cars, trucks, buses, and taxicabs, because to date they are noisy and rough. However, a number of them are studying aircraft brake design with a view to improving these units on vehicles. The vast experience gained on Army landing strips and the limited runways on baby flat-tops and other aircraft carriers, has given brake engineers an unprecedented proving ground, both in respect to the number of service tests and the variety of operating conditions. It is probable, many of them believe, that the vehicle engineers will benefit first from brakes in the post-post-war period.

But, in general, the American motoring public will have to be satisfied with new cars with few modifications until research and development stimulated by the war's engineering effort can be adopted in later models.

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SHOT PEENING

Offers Possibilities of Stress Relief

Among the war-born manufacturing techniques which are destined to come into wide peace-time use in the post-war period is shot-peening of highly stressed surfaces. Although considerable work had been done along these lines before the war, shot-peening developments have been rapid to meet the exacting demands of armament manufacture.

There have been two schools of thought about surface finishing in the automotive industry. One has held that honing and lapping working surfaces to a high polish gave the best results. Another group held that this surface finishing was inadvisable, because stresses were set up in the surface of the part which caused premature failure.

Several engineering societies are now working together on standards and specifications of the sizes and quality of shot to be used, and a procedure for its use on various types of parts. Air blasting of the shot against the part is a widely used procedure, but tumbling barrels are sometimes employed. It has been found often that the working surface, although appearing to be rough under a magnifying glass, is improved by the shot-peening.

TRUCKS AND BUSES

Should Be Designed For Greater Utility

Vehicle operators want safe, unornamented, capable units that feature ease of repairing and maintenance, according to a recent survey of more than 300 leading automotive engineers in charge of commercial vehicle fleets from coast to coast. Specifically, these engineers want the designer of post-war trucks and buses to consider:

Cooling systems which really cool, which will maintain their efficiency, and can be readily serviced; accessibility of critical parts to encourage mechanics to keep them in proper repair; removable powerplants, so the engine can be removed for repair and another be quickly installed to lessen lay-over time of the truck or bus in the garage; better cold-starting characteristics of the engine; more comfort for drivers; and less ornamentation.

BRAKE DRUMS

Salvaged by Spraying to Replace Removed Metal

Striking example of the value to industry of coördinated engineering research is the current development of aluminum brake drums stemming from a project of the Society of Automotive Engineers' transportation and maintenance engineering program. To salvage worn brake drums, the Brake Drum Committee recommended hot metal spraying of worn drums, followed by grinding to size. This report resulted from exhaustive tests of various other methods. An aluminum drum, thus sprayed, showed remarkable advantages in test. A large municipal bus line has ordered a number of such drums for actual service tests. Early reports indicate better wearing qualities, longer brake band life, and no brake squealing. Important implication is that unsprung weight could thus be decreased, resulting in more rider comfort.

TRACTORS

Will Find Greater Use On the Farm

Manufacturers expect competition from new entrants into the tractor field soon after the end of the war. Several surveys made recently by farm journals indicate increased interest in farm tractors ranging down in size to small hand cultivators.

Makers of small gasoline engines have been working on expanding the pre-war use of these machines by hooking them up to farm tools as a part of their post-war expansion. More than 280 companies in the United States have been making internal-combustion engines during the war. Some of these expect to be in the tractor business as soon as possible.

STEERING

Will Be Made Easier By Power Developments

Power steering developments are to be expected if the present trend of labor agitation for greater ease in truck and bus driving continues. A bill, already in the hopper of one state legislature, requires such devices on larger vehicles.

SYNTHETIC TIRES

Have Bright Prospects For the Future

Recent grueling tests of synthetic automobile tires have cheered automotive engineers, in view of the 1,000,000-ton capacity of synthetic rubbers now in production in the United States. Pre-war use of natural crude rubber by the automotive industry was about 600,000 tons a year.

As fabrication techniques improve under war-time pressures, the prospect of better synthetic tires is bright. Although the synthetic materials are more costly than crude rubber was before the war, improved techniques of manufacture and better control of the consistency of the synthetics may result in competitive prices.

UNDER DISCUSSION

Are a Number of Automotive Developments

A group of automotive engineers, who recently mêt informally in Cleveland, listed the following developments as being the most important for post-war consideration, in this order:

1. Improved transmissions. In this discussion, the questions of inconvenience in gear shifting and the cost of maintenance of the conventional transmissions were emphasized. Some work, it was reported, has been done on infinitely variable transmissions, but the problem of positive holding is an involved one.

2. Better brakes. Some work was reported on the adoption of aircraft types of brakes, and considerable interest was aroused on the possibility of aluminum drums lined with a hard wearing surface.

3. More adequate ventilation. Most of the engineers felt that no inexpensive way to improve ventilation control could be found without compromising with appearance. Suggestions of slotting the body and fitting adjustable vanes were discounted for this reason.

4. The war has emphasized the need of lower maintenance cost for passenger cars as well as commercial vehicles.

Flying Electronics

Safety and Consistency of Operations are Two of the Factors of Aviation Which Can be Promoted Rapidly Through the Use of Proved Electronic Devices. Plans of the CAA for Post-War Flying Embrace Radio Equipment that Will Give Aid to Both Commercial and Private Pilots

By VIN ZELUFF
Associate Editor, *Electronics*

TO BECOME a full-fledged industry, aviation must be able to provide its own unique method of transportation in almost any kind of weather. Although short delays can be forgiven by the traveling and shipping public, holdups of several days because of limited visibility cannot easily be tolerated for a method of transportation whose essence is speed.

For many years, it was almost impossible for an aircraft pilot to determine the true height of his plane above the ground, or even his location in respect to his destination. These are still problems in some respects, but they have been solved for commercial planes by applications of electronics. Postwar, the private flyer, too, may benefit from the decreased costs of such equipment that will result from techniques learned during military use.

When the weather is such that visibility is limited to a very few feet, flying was far from enjoyable before the days of automatic radio compasses, absolute altimeters, radio ranges, and so on.



Courtesy United Air Lines

Aircraft radio transmitters and receivers receive periodic adjustment

As private flying becomes more popular, accurate radio direction finders will undoubtedly approach a cost near that of good automobile radios. The radio range is available to anyone with a radio receiver, but radio altitude-measuring equipment will not be common on private planes for quite a while, due to its weight and cost.

Radar enables the pilot to contact the ground and to feel his way electronically. He can determine the characteristics of the ground or any object which may be within range of his beam of concentrated radio energy. This type of navigation has been a dream since shortly after the last war, but has become a reality through greatly increased knowledge of microwave technique and of electronic circuit characteristics.

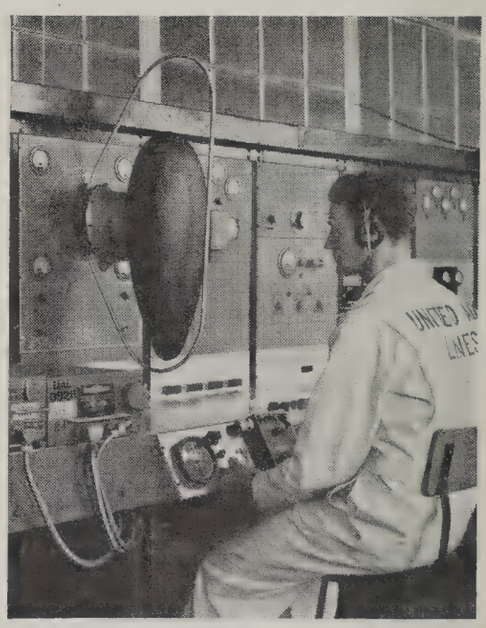
An electronic ice indicator warns a pilot of the formation of ice on wing surfaces, a very serious problem. It can determine the rate at which the ice forms so that a pilot can change his course to one having more suitable weather conditions. The propeller and the carburetor also can use ice detectors. In mass production, a simple ice detector should sell for less than 50 dollars.

HOW MUCH GAS?—Accurate determination of the amount of gasoline in the tanks while in flight is another problem that has been solved by electronic equipment. In very large transports and bombers, the electronic gage has already replaced the simple float-type gage that does not provide accurate readings even during normal flight.

Electronic gas gages are being experimented with that measure the capacitance between a number of plates immersed in the gasoline, the capacitance being a function of the height of the gasoline between the plates. Commercial planes need such an accurate fuel gage, since any excess fuel carried merely because of uncertainties is reflected in higher operating cost to the airline.

Electronic engine controls of the future will take over engine adjustments and leave the pilot with the necessity of controlling only the engine power. The control will make all of the necessary engine adjustments, selecting the optimum operating conditions for the engine horsepower desired. At present, an electronic supercharger developed by Minneapolis-Honeywell controls the boost, or manifold pressure of aircraft engines in military planes. This control maintains a predetermined air pressure at varying altitudes by controlling the setting of the supercharger's waste gate.

An electronic carburetor control



Automatic direction finders are checked for accuracy before installation in an aircraft. The blimp-shaped casing to the left houses the antenna

coupled with the electronic engine knock detector would provide a control which would automatically adjust an engine to the maximum economy consistent with safe engine operating characteristics. This would adjust the fuel supply until one or more of the cylinders were detonating and then enrich the mixture slightly until the knocking ceased. Such control is expected to save as much as 10 percent of the fuel, compared with an engine

operated in the conventional manner. In large planes, this saving in fuel alone would soon pay for the cost of the instrument.

AIRPLANE RADIO—Completely automatic radio compasses in which the loop constantly and automatically indicates the direction of the desired radio transmitting station are now available. These units stand up indefinitely under any conditions of operation yet experienced by our armed forces.

The magnetic compass is very limited as a guide, because it can only show direction—it cannot tell a pilot his location. Unlike the magnetic compass, the electronic radio compass is not dependent on only one north pole. Each radio transmitting antenna whose signals can be received by the radio compass becomes in effect a "north pole." When the pilot tunes to a radio station, the radio compass shows the direction to that particular antenna.

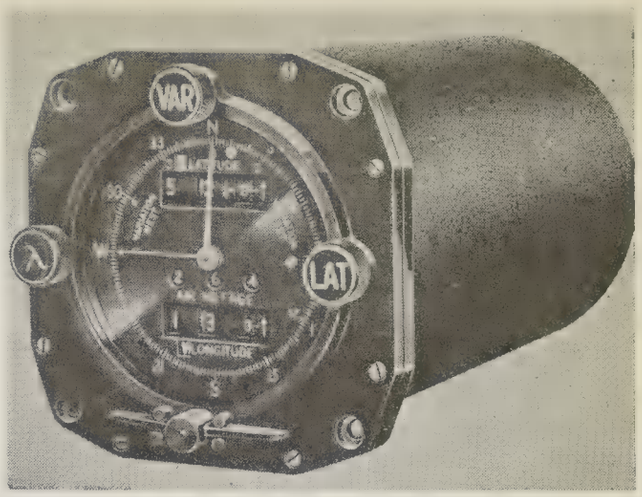
The pilot flying through soupy weather uses the radio compass to receive two or more stations and records the angle of each on a map. He draws a line from each at the angle recorded and the point at which the lines cross is the location of the plane. To reduce the plotting time involved still further, the Bendix dual-automatic compass was developed. With this instrument, the pilot can get his bearings from any two stations by merely glancing at the azimuth indicator at any time.

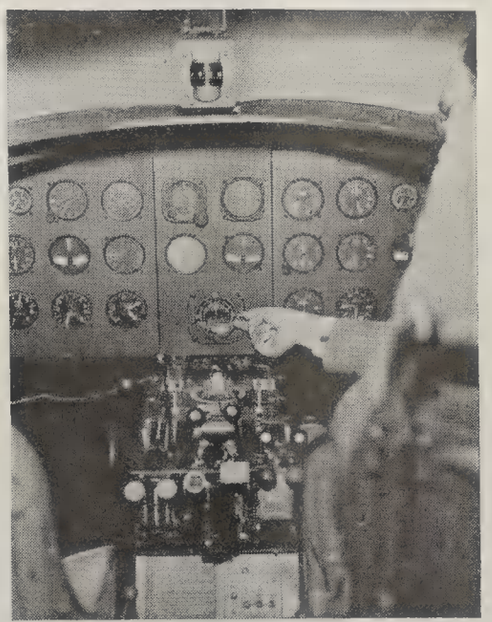
One of the recently revealed secrets of B-29 Super-Fortress raids on Japan is the "air position indicator," an instrument that, for the first time in the history of navigation on the sea or in the air, gives continuous readings of latitude and longitude plus a continuous record of nautical air miles flown. The air position indicator, developed by the Eclipse-Pioneer division of Bendix in co-operation with Army and Navy air forces, automatically makes calculations which ordinarily would require a navigator to work for hours with charts, basic navigational reference books, star-sighting sextants, a chronometer, parallel rules and dividers, and does this accurately even during evasive action when no navigator could follow the maneuvers of the plane and keep his bearings.

POST-WAR ELECTRONICS—The arrangement of electronic aircraft equipment planned by the CAA for post-war use contemplates that one aircraft receiver will be sufficient for minimum navigation and air traffic control requirements. This receiver would receive navigational guidance along the airway using the airway radio ranges, and would respond to the runway localizers of the instrument landing system when instrument approaches are necessary. It would also receive the various voice channels provided for communications along the airways and the simultaneous voice channel on the runway localizers, in addition to the several radio channels used by the control towers for air and ground traffic.

For pilots desiring additional guidance, a second receiver is required

Right: Dial of the Bendix air-position indicator that automatically computes latitude and longitude for navigators of the air lanes. Below: Typical aircraft instrument panel with the air-position indicator centrally mounted





for the radio markers along the airways and on the instrument landing system. A third receiver is required for the glide path if the pilot desires to make use of this part of the instrument landing system. A fourth receiver would tune to the visual distance-indicating facilities, and a fifth receiver would be required if automatic direction-finding navigation was to be used.

The very-high-frequency electronic instrument landing system perfected by the CAA has now been adopted by the Army, Navy, and most of the nations of the world as their standard. Some 58 of these systems will be in operation by the end of 1946. Eight are now installed and ten are underway at present. In addition, the CAA is installing 50 instrument landing systems for the Army, 35 of which have already been completed.

The localizer unit of the instrument landing system will be operated in the 108 to 112-megacycle band, and will have a simultaneous voice channel for radio communication by the airport traffic control tower with aircraft making instrument approaches. The glide path will operate on six frequencies in the band from 328.6 to 335.4 megacycles.

Delayed for two years, because of war necessities, is the conversion of the radio ranges from low frequencies in the 200- to 400-kilocycle band to very high frequencies in the 112- to 118-megacycle band. This range program is now going forward and it is anticipated that over half of the present 37,000 miles of airways will be served by VHF ranges by July, 1946.

Other phases of the CAA's post-war plans for air navigation facilities call for providing a good system of low-frequency, high-powered facilities in the United States to permit long-distance flights by direction-finding upon completion of the VHF range program. These low-frequency, high-powered stations may well take the form of omni-directional range stations, and most certainly will be designated to permit directional guidance without the necessity of the aircraft being equipped with direction-finder receivers.

AIR TRAFFIC CONTROL—Post-war plans envision further that probably two VHF frequencies will be provided for airport traffic control communications with other than those aircraft receiving instructions over the voice channel of the runway localizer. One frequency would be used for aircraft in the air flying locally around the airport, and the other frequency for aircraft on the ground in connection with taxying and parking instructions. It is proposed that all airport traffic control communications, other than those over the voice channel of the localizers, will be conducted in the 118- to 122-megacycle band. The 122- to 132-megacycle band has been set aside mainly for aircraft-to-ground transmission frequencies.

The VHF ranges will guide the pilot along the airways and provide him with weather and traffic-control information. Initially, it is planned that one simultaneous voice channel will be available on all ranges for ground-to-air two-way radio communications. If it is found that one voice channel will not be adequate to provide two-way communications for both traffic control and weather information at a given location, consideration will then be given to the matter of providing an additional channel so that one channel will be available for traffic control transmission and one for weather transmissions, whichever is the more practicable.

One additional device, highly desirable as a monitoring or safeguarding facility in airport traffic control towers, is a "scanning screen" operated on electronic principles which will permit the airport traffic controller to visualize the actual positions of all

aircraft at all times within a predetermined radius of, say, 25 miles from the airport. These screens will permit monitoring the movement of aircraft on the instrument approach system so as to detect any hazardous condition that may possibly develop as a result of a pilot not following instructions or as a result of some failure in aircraft equipment. They also would make it possible for the airport traffic controller to arrange the flow of departing aircraft with more certainty as to the positions of approaching aircraft.

HOW FAR APART?—The CAA also contemplates the use of a cathode-ray tube in the aircraft on which will be displayed indications portraying the vertical separation between the aircraft in which the device is installed and other aircraft in all directions within fixed vertical limits. It operates on the principle of varying the frequency of a low-powered transmitter on board each aircraft by a sealed aneroid capsule, so that changes in altitude will vary the frequency of the aircraft's position-indicating transmitter.

Another approach to the collision warning indicator is through the use of radar technique. This would have an effective range in all directions, rather than just the front hemisphere or a portion of one hemisphere as now used for military purposes.

Ten carloads of radar apparatus loaned by the Army and Navy are being used by a CAA experimental station at Indianapolis to conduct tests of radar aircraft control. Two objectives are perfection of the screening device previously mentioned which will permit the tower controller to visualize the actual positions of all aircraft within a radius of 25 miles, and a collision warning device to be installed on the instrument panel of the plane, which would give constant visual indication of the relative position of other aircraft within a certain radius. With at least 150 plants now making radar equipment, much production know-how in this field will be available for commercial radar equipment when military needs fall off.

DIELECTRIC-HEAT UNITS

Need Shielding to Prevent Causing Radio Interference

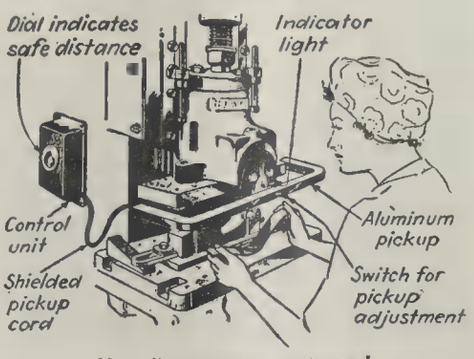
RADIO interference measurements in the vicinity of induction and dielectric electronic heating units reveal that only the dielectric-heating types need to be shielded to prevent interference with radio reception. This means that the induction-heating units so widely used today in industry for quick and localized heating of metals cannot be blamed for mysterious squeals similar to those that created a scientific mystery some years ago until they were traced to diathermy units in hospitals.

As with diathermy units, shielded enclosures are the prescription for the industrial dielectric heating setups used to heat plastics, to dry glue in plywoods, to sterilize food products, and to heat practically any other nonmetallic material. If a single cage will not suffice, a double screen cage with metal weather-stripping sealing the edges of the entrance door is almost certain to squelch any tendencies to broadcast. Where one of these electronic heating units must straddle a conveyor that is carrying work continuously to and from the machine, so that entrances must be open while power is on, metal tunnels at entrance and exit will effectively trap emerging waves. These work on somewhat the same principle as light-trap doors of photographic darkrooms.

FINGER GUARD

Operates by Change in Electrical Capacity

AN ELECTRONIC safety guard for punch presses that eliminates the usual phototube arrangement and permits adjustment of the critical distance at which



Her fingers are protected

the press shuts off, valuable when the press is used for different sizes of materials, has been developed at North American Aviation. The electronic circuit is arranged to operate relays that actuate contacts and solenoid air valves on the press.

Mounted on the press is an aluminum rod that connects to the control unit. When the operator's hands or other parts of the body come near the rod, a change in the electrical capacitance of the circuit takes place which causes it to prevent the operation of the press until the hand is removed from the protected zone. A dial on the control unit permits the circuit to be adjusted to different sensitivities for the proper distance setting.

FOOD AGING

Speeded When Ultra-Violet Lamps Are Used

AN ELECTRONIC guardian for food storage space is the Sterilamp ultra-violet tube, a device which resembles a slenderized fluorescent lamp and kills bacteria and mold either on food surfaces or afloat in air. In a patented process for the rapid tenderization of beef, the temperature in the beef aging room, protected by lamps, is raised from 36 to 60 degrees and the time required for the natural process of ripening is reduced to about one tenth of the time previously required. Without a bactericidal agent, the high temperature, combined with the high humidity necessary to prevent surface drying and accompanying injury to the meat, would result in surface mold and slime, causing serious wastage.

In cheese aging, it is necessary to maintain a relative humidity of 80 percent to reduce dehydration. To speed ripening when using Sterilamps, the temperature is raised to an average of 45-50 degrees—about 15 degrees higher than in unprotected aging rooms. Thus, the lamps permit acceleration of the cheese-ripening process to a fraction of the time previously required and reduce shrinkage by dehydration.

In addition to the bactericidal rays, the Westinghouse lamps produce in the air a small amount of ozone, a colorless gas used commercially for purification of water and foods, particularly in egg and apple storage rooms. Ozone scatters rapidly from the lamps and is circulated throughout the storage space, and acts as an additional weapon to halt mold growth. At the same time, the ozone concentration in food storage and processing rooms properly equipped with the bactericidal lamps never exceeds a few tenths of one part per million of air, which is too low to injure even sensitive foods.

LIGHT MEASUREMENT

Aided by Use of Electron Multiplier Tube

IN THE manufacture of color film, it is necessary to determine the density contribution of each of the three dye layers separately. The insertion of filters in a conventional light-beam system for separate measurements in the green, blue, and red spectral regions reduces the available light so much that conventional photoelectric densitometers used for black-and-white film do not get enough light to excite the phototube. Increasing the size of the lamp used would work for green and blue, but not for red because the ordinary phototube is relatively insensitive to red.

This intriguing photoelectronic problem was solved by the research laboratory of Ansco by the substitution of the electron multiplier phototube for the ordinary type, and addition of a special electronic amplifier working directly from a stack of ten miniature 67½-volt B batteries giving a total of 675 volts.

Electrons emitted from the cathode of the tube under the influence of light bounce in turn from each of nine reflecting plates called dynodes. Each dynode has the characteristic of giving off many more electrons than hit it, so that after nine such electron multiplications the output may be as much as 20,000 times greater than that of an ordinary phototube—enough to actuate the amplifier and meter.

Other applications of this new direct-reading high-sensitivity densitometer include analysis of chemicals, measurement of colors of materials by reflected light, and analysis of the x-ray diffraction patterns and line spectrograms that are now expanding so rapidly in industrial usefulness.

Engines Of The Air

Kerosine Lamps, Exploding Because of Gasoline in the Burning Oil, Paved the Way for the Development of the Gasoline Engine. At First there was a Surplus of Fuel; then Chemists were Hard Put to Produce Enough Efficient Fuel to Meet Demands of Automobiles and Airplanes

PROPERLY, the chemical story of aviation begins with the explosions of kerosine lamps three quarters of a century ago. From the steps then taken to remove the explosion hazard from kerosine grew the motor-fuel industry of today and upon that depended the development of the internal-combustion engine. Without the internal-combustion engine, aviation as we now know it would be completely impossible. While automobiles could be satisfactorily powered by electricity from storage batteries or by steam engines, the weights entailed per horsepower by either of these prime movers become prohibitive in the air. But the internal-combustion engine was developed primarily for highway travel under the stimulus of the immense quantities of cheap gasoline available in the automobile's early days as a by-product of kerosine production.

The dangerous tendency of lamps to explode was caused by the desire of oil refiners to produce kerosine faster to meet increasing demand. The unfortunate method chosen was to leave some gasoline in the kerosine. As is well known, gasoline vapor, with air, forms mixtures that explode when ignited. That is fine in an engine where the explosion can be harnessed to do work, but in lamps it was disastrous. When the cause of exploding lamps was found, steps were taken to insure that every bit of gasoline was stripped from the kerosine during manufacture.

UNWANTED GASOLINE—This was a hardship for oil refiners who knew no way to dispose profitably of the unwanted gasoline. Later that picture was reversed by the popularity of the gasoline-driven automobile. Although those two events are mentioned together, actual decades of development of internal-combustion engines were needed before there were enough of them to use up the gasoline available.

When the 20th Century arrived, a few carriages in the welcoming procession ran on rubber bicycle tires, but with no horses to pull them. Some drew their power from electric motors run by storage batteries. Others used smelly, noisy gasoline engines. Between the two arose active competition. By that time petroleum refiners were almost overwhelmed by accumulations of excess naphtha, or gasoline, which they had to produce along with coal oil. This surplus fuel gave the gasoline-powered vehicle a distinct advantage in the struggle for survival with its electric rival. Power from gasoline was cheap but by no means as dependable as electricity—or, for that matter, as the steam which some pioneer road vehicles generated by using kerosine as fuel. The outcome of this competition hinged on making gasoline engines dependable.

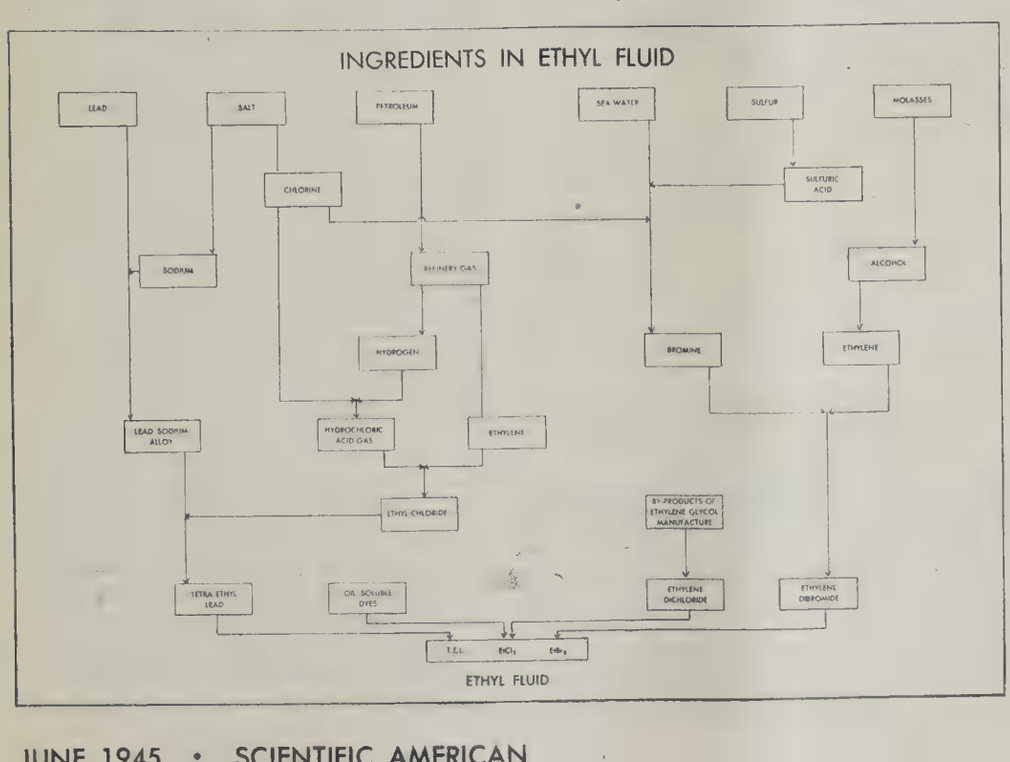
The steps leading to mechanical perfection of internal-combustion engines are not part of this story. However, exploding lamps of the 1860's and the change they forced in petroleum refining were crucial factors in vital



Courtesy Standard Oil Company
Storage tank for high-octane fuel

modern developments. Without bountiful supplies of gasoline, which refiners had to produce in making kerosine, the essential spur to mechanical development of mobile gasoline engines would have been missing.

As early as 1903, the Wright brothers flew because gasoline had been a drug on the market 30 years before and on that surplus of gasoline rested the development of the Otto-cycle engine. Automobiles could have developed



with electric or steam power, but not airplanes.

Quite naturally, fuel has had to develop along with engine design. Early engines were built to burn the by-product of kerosine refining and the result was so successful that soon the by-product had far outgrown the need for the original material. Electricity had effectively invaded the field of lighting and was crowding out kerosine. Meanwhile, the growing numbers of automobiles multiplied the demand for gasoline to overwhelming proportions. Indeed, demand seriously threatened to use up all of our petroleum resources.

CRACKING—At this juncture the newly developed cracking process offered a solution for the trouble by greatly increasing the amount of gasoline obtained from each barrel of crude oil. That was about 1912, and during the succeeding decades this process in many modifications was utilized throughout the oil refining industry. In effect, gasoline production was doubled without requiring any more crude oil. This was a big jump ahead.

But early gasoline engines wasted large proportions of the gasoline fed to them. They were too inefficient for profitable flight. At the same time, possible depletion of oil sources threatened the automotive industry and spurred it to seek higher efficiency. Theoretically, gasoline engines would produce more power from fuel if the gaseous mixture could be put under greater pressure in its cylinders before ignition. Simply change the stroke of the piston and get more power—simple until one tries to do it. Instead of more power, the modified engine produces less, and at the same time it hammers and knocks as if it would break itself to pieces. The increased pressure changes the nature of the explosion, makes it resemble the sudden blow of dynamite and not the normal, much slower burning of a proper cylinder charge.

Different fuels (gasoline, coal tar benzene, cracked gasoline, and so on) behave differently and tiny amounts of various substances added to fuels change this knocking characteristic. Tetraethyl lead, now almost universally added to motor fuels, proved to be the most potent of these additions. It regulates the rate of burning of the cylinder charge. Even under much higher pressures than those in general use, power is delivered smoothly to the piston at a rate slow enough to allow it to do a maximum of useful work. An actual gain of as much as 80 percent in the output of an engine can be realized by the use of high compression and 100-octane fuel, in contrast to low compression and the 73-octane fuel common on the American market.

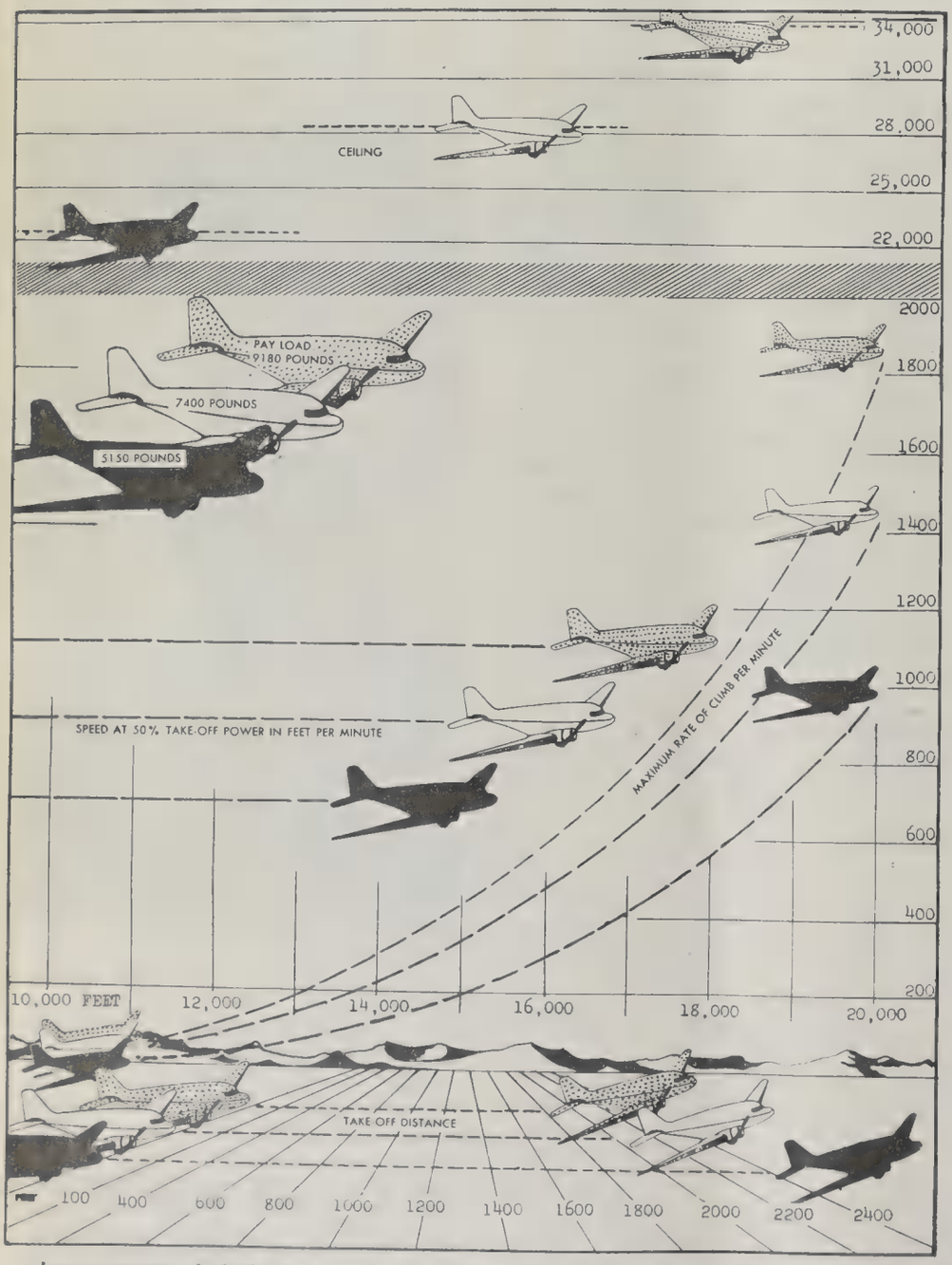
Tetraethyl lead gave a tremendous impetus to the development of more efficient engines and at the same time of more effective fuels to use in them. Consistent flight became commonplace because of the increased load-carrying capacity of planes realized through heightened efficiency of power production. Numerous other methods of producing fuels adapted to the re-designed engines also followed the growing demand for them. And that trend continues toward the goal of maximum power from minimum fuel and smaller engines.

By subjecting petroleum fractions—gas oil, particularly—to high temperature and great pressures, carbon molecules can be literally cracked to bits. Many of the resulting particles fall within the desired range for motor fuel, others are too small, and still others come from the process as a sooty deposit of carbon stripped of its essential hydrogen. This thermal cracking, by doubling the yield of gasoline per barrel of crude oil, proved a practicable operation in spite of the considerable wastes accompanying it.

CHEMICAL PROMOTERS—One result of thermal cracking is to produce hydrocarbons of the unsaturated or olefin family. These enter with relative ease into chemical reactions, while saturated hydrocarbons are quite inert. Thus it becomes possible to utilize the small molecular fragments produced by cracking to build up larger molecules by chemical means. In spite of their superior chemical reactivity, these olefins react much better and combine more readily in the ways desired if a promoter, or catalyst, is present.

The fragments produced by cracking may subsequently unite among themselves in a variety of new molecular patterns. Certain foreign substances, some natural clays for instance, promote and control these recombinations of fragments and force a larger proportion of them to form desired products. In this way less oil is wasted as gas and more gasoline is produced from the same amount of original oil. Furthermore, the gasoline from catalytic cracking, as this process is called, is better because it has a higher octane number. The gases from the process may be used in making polymer or alkylated gasolines, now prominent as aviation fuel for military and transport services.

This discussion of anti-knock fuels and their characteristics bears directly on the subject of cracking and other methods of enlarging the yield of motor fuel from crude oil. Not only does cracking, both thermal and catalytic,



Improvement of fuels has enabled airplanes to carry heavier loads, and to fly higher and faster. The dotted planes on the chart are powered by 100-plus octane gas; the white planes by 100-octane gas; and the black planes by 87-octane gas

produce more fuel per barrel of crude oil, but at the same time the product has an improved octane number and hence is more valuable. This is vitally significant in view of the general adoption of more efficient high-compression engines in automobiles and airplanes. In the latter, where weight is the vital



Alkylate, an important ingredient of 100-octane aviation gasoline, is produced at this sulfuric acid alkylation unit of the Texas Company

consideration, increased compression and other factors have resulted in weight reduction of engines from 3½ pounds per horsepower at the time of World War I to somewhat less than one pound per horsepower in World War II. That difference is vital to air transport in war and in peace.

FUEL EFFICIENCY—Once a true measure of fuel efficiency was established and types of fuels were classified on that basis, certain conclusions appeared from the classifications. Hydrocarbons whose molecules are straight chains usually knock badly. The greater the branching of the chain, the greater the octane number. Double bonds in some cases raise the octane number, in others depress it. Such observations gave the petroleum industry invaluable guidance in its efforts to improve fuels.

Several important processes based on these considerations are operated on a huge scale. Polymer, alkylated, and hydrogenated gasolines are produced by controlling in various ways the forms taken by the re-uniting fragments of molecules produced in cracking both petroleum and natural gas. Each of these products possesses a high octane number and each can materially raise the octane number of a mixture of which it forms a part. Additions of tetraethyl lead to blended fuels of this kind further raise the octane number so that it is possible to produce commercially on a huge scale fuels as much as 15 to 25 percent more effective in an engine than pure iso-octane, once considered an unreachable fuel goal.

Polymer gasoline is produced from the gases of thermal cracking by causing their molecules to reunite in the presence of a catalyst such as phosphoric acid. The catalyst seems to exercise a directing and promoting function in encouraging the various gaseous molecules to unite in the form of hydrocarbons in the gasoline boiling range. Since hydrocarbons of this type possess high anti-knock values, the resulting motor fuel is especially desirable.

Alkylation also yields highly desired branched hydrocarbons. Its raw material is primarily the butanes and butylenes, hydrocarbons of four carbon atoms, and these are rearranged to form molecules of eight carbon atoms, just the kind needed for aviation fuels with octane numbers of 100 or more. Particularly important about alkylation fuels are their high initial octane numbers and their sensitivity to small additions of tetraethyl lead. Thus, adding small amounts of lead to alkylate gasolines causes a much greater effect than would the same amount of lead added to straight run or thermally cracked gasoline.

Commercial production of iso-octane itself is accomplished by submitting the so-called butane fraction separated from thermal or catalytic cracked gases —the fraction consists largely of the olefins of four carbon atoms—to selective polymerization and subsequently hydrogenating the product. The iso-octane produced possesses an initial octane number of 100 and even better performance can be obtained by addition of tetraethyl lead.

FUEL FROM WASTES—A further important fact about modern chemically made motor fuels is that the raw materials used in their production are to a large extent the gases from the cracking process once burned as fuel. Cracking breaks up large molecules, but polymerization, alkylation, and other catalytic processes reassemble small molecules into larger ones. Not only are important new fuels produced by these processes, but economies in the utilization of crude oil are effected at the same time.

Clearly the purposes of aviation and the conquest of the air have utilized to an essential degree the power of chemistry to alter and improve the fuel of flying engines. The intimate relations between the two sciences of aeronautics and chemistry by no means stop with the fuel supply. The structure of the plane, its metal and plastics parts, its lubrication, and many other elements that contribute to successful and efficient flight owe their origin or perfection to chemical processes of one kind or another. However, when the whole matter is summed up and its elements evaluated, no single development has had anything like the significance of the gasoline-powered, internal-combustion engine. And that owes its practical existence to the explosion of kerosine lamps many decades ago.

STERILE BOTTLES

Indicated by Color-Changing Seals

Visible proof that the contents of a particular bottle have been sterilized after the seal was applied is offered by a new type of cellulose band adapted to seal various types of containers. The band is colored with a dye which changes color when it has been heated to sterilizing temperature. A dark green seal may, in one type now offered, change to orange when it has been heated to a temperature high enough to sterilize the container's contents. Originally proposed as a method of preventing the drawing of blood for transfusions into unsterile bottles, seals of this type are expected to have important usefulness in other ways.

PENICILLIN PRICES

Pushed Down by Rapid Production

Less than two years ago producers were frantically trying to enlarge their production of penicillin to meet the tremendous demand for this wonder-working substance for the Armed Forces. Now, not only has that goal been exceeded far enough to allow placing penicillin in civilian drug stores and hospitals, but actually production has reached the point where a price war of at least minor proportions is in progress. Improvements in production methods and yields so far effected enable production at far less cost than was originally estimated. This powerful drug, hailed as the most valuable development of modern medicine during the war period, is now available to any physician needing it.

PASS THE ARSENIC

But Be Sure to Try The Fluorine as Well

If you insist on eating arsenic but wish to avoid being fatally poisoned by it perhaps you can save yourself by taking highly toxic fluorine compounds at the same time. There is no reason why one should wish to take lethal doses of arsenic but, if they should, fluoride may supply an antidote that can be used in certain cases. A report of recent experiments with rats shows that drinking water containing potassium fluoride both before and after the rats took arsenic trioxide mixed with sugar prevented the death of the experimental animals. While the finding is interesting and may shed light on the action of arsenic taken into the human system the method is hardly to be recommended for first aid since an overdose of fluoride, familiar as ant poison, kills one quite as dead as arsenic does.

Lubricants For Air Power

Airplane Engines, Operating at High Temperatures, Need Strong Oil Films to Protect Moving Parts. Careful Research by the Petroleum Industry Has Produced Lubricants that not only Resist Deterioration under Severe Conditions, but also Carry Away Heat from Pistons

By B. W. STORY and E. A. MARTIN*

LARGELY because of European influence, most of the early airplane engines were lubricated with castor oil, while automotive engines operating on the same principle were running almost exclusively with petroleum oils and with generally better results. These airplane engines were no more difficult to lubricate than some automotive engines of that period and it was soon found that petroleum oils of similar character but of somewhat heavier body were superior to castor oil. While many improvements have been made in airplane engine oils since that time, the supremacy of petroleum lubricants has not yet been seriously challenged.

Early airplanes flew neither high nor far and frequent overhauls were accepted as a matter of course. Within the past ten years, however, these conditions have changed rapidly. Engine output has been stepped up from a few hundred to over two thousand horsepower and operation between overhauls has been lengthened from around 200 to 800 hours or more. The modern airplane may take off at sea level at temperatures ranging from — 40 to + 100 degrees, Fahrenheit, and from either extreme may, within a short time, encounter temperatures as low as — 70 degrees, Fahrenheit, at altitudes of 20,000 feet or more.

High temperature and pressure between moving parts cannot be avoided when internal combustion engines are built to the power output and weight standards of modern aviation. Hence, the lubricating oil must function not only as a lubricant under exceptionally severe conditions but must also serve to carry heat away from pistons and other parts of the engine which otherwise would become too hot for successful operation. Furthermore, as the oil is cooled and recirculated through the engine many times before it is finally consumed, it must continue to perform its various duties with the least possible deterioration. Hence only the most specialized oil can survive.

Petroleum oils are composed almost entirely of hydrocarbons and therefore have certain inherent properties which cannot be changed completely. At elevated temperatures, in the presence of oxygen, they will oxidize to form acidic compounds which then proceed to form what are generally termed sludge—tar and asphalt. At still higher temperatures these oils will crack or break down into smaller compounds and carbon which are quite unfit for lubrication. While petroleum refiners cannot wholly suppress these natural tendencies of hydrocarbons, they can modify them and improve the oil for any given purpose in three ways; (1) crude selection, (2) choice of refining methods, and (3) adding some material to the oil which will impart properties not obtainable from the oil alone. These materials are generally called addition agents or additives and they have a wide variety of uses.

STRONG FILMS—Airplane engines require a fairly heavy bodied oil in order to provide a strong oil film in the hotter zones of the engine. All petroleum oils increase in viscosity as their temperature is lowered and at the lower atmospheric ranges heavy oils have a high resistance to motion where clearances are small, as on cylinder walls and in bearings. Because it is often necessary to start engines in cold weather, it is important to select oils which give the least change of viscosity with temperature. This property of oils has been calibrated to a scale known as "viscosity index" (V. I.) and aviation oils are generally known as high V. I. oils, meaning that their change of viscosity with temperature is comparitively low. As a class, the so-called paraffinic types of oils are good in this respect. The naphthenic or aromatic types are not as good and are consequently less generally used in this field.

All paraffinic oils contain wax which is liquid when warm, but at low temperatures will crystallize and cause the oil to solidify, making it difficult to pump and distribute properly throughout the engine. Most of the wax is removed by suitable refining steps, but generally it is not economical to de-wax heavy oils so that they will flow freely at temperatures low enough for good aviation practice. Fortunately, addition agents have been found which effectively reduce the temperature at which paraffinic oils will flow. Commonly known as "pour depressants," these agents are widely used for this purpose and have saved industry much expense as well as much good oil that otherwise would have been lost through excessive de-waxing. Only small amounts are required and in most cases less than 0.5 percent is sufficient even for heavy lubricants.

Petroleum crudes always contain compounds which are unfit for lubrication of combustion engines and these must be removed as completely as possible. For years it was not commercially feasible to do this in many cases and the production of airplane engine oils was limited to a few crudes, notably of the Pennsylvania type, which

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Figure 4: Oil inhibited by an additive is a better lubricant than uninhibited oil. Only 13 hours' operation with straight mineral oil produced the sludge on the piston thrust face and crown in the two pictures on the left, while 30 hours' running with an inhibited oil caused the lesser amount of sludge in the two pictures on the right

were amenable to refining processes then available. With the advent of propane de-asphalting and solvent refining, this situation was changed completely. Superior lubricants can now be made from crudes which only a few years ago were considered hopeless for aviation use.

INHERENT VALUE—Petroleum refining, however, is essentially a subtractive process and relies entirely upon the value of materials which exist in the crude. While excellent lubricants have been and will continue to be made from straight petroleum, there are limits beyond which refining engineers cannot go without the assistance of addition agents. These limits have already been surpassed in the case of lubricants for certain types of gears and high-speed Diesel engines where pure petroleum is admittedly inadequate. As operating conditions become more severe, it seems quite certain that further requirements of airplane engine oils can be met only by the use of additives.

The groundwork of discovering and improving such additives is a job that must be done in the laboratory. To attack a lubrication problem directly through flight tests would in many cases be expensive and hazardous because, as in all research work, failures far outnumber successes. Preliminary tests, therefore, must be made but experience has shown that it is unsafe to depart too far from conditions of actual service because there is danger of obtaining wholly unreliable results. In other words, if the problem involves an airplane engine, such an engine or at least parts of it should be used. It is sometimes permissible to accelerate a test by employing conditions that are abnormally severe but in so doing some correlation with practice should be established.

Figure 1 shows a single cylinder test engine which employs an air cooled cylinder and piston assembly of current aviation design and has an output of 25 horsepower.

Figure 2 shows a test unit which will accommodate large modern cylinders with an output of 125 horsepower and represents an additional step in testing aviation oils. If satisfactory performance is indicated throughout these preliminary tests, the oils are then candidates for trial in actual flight.

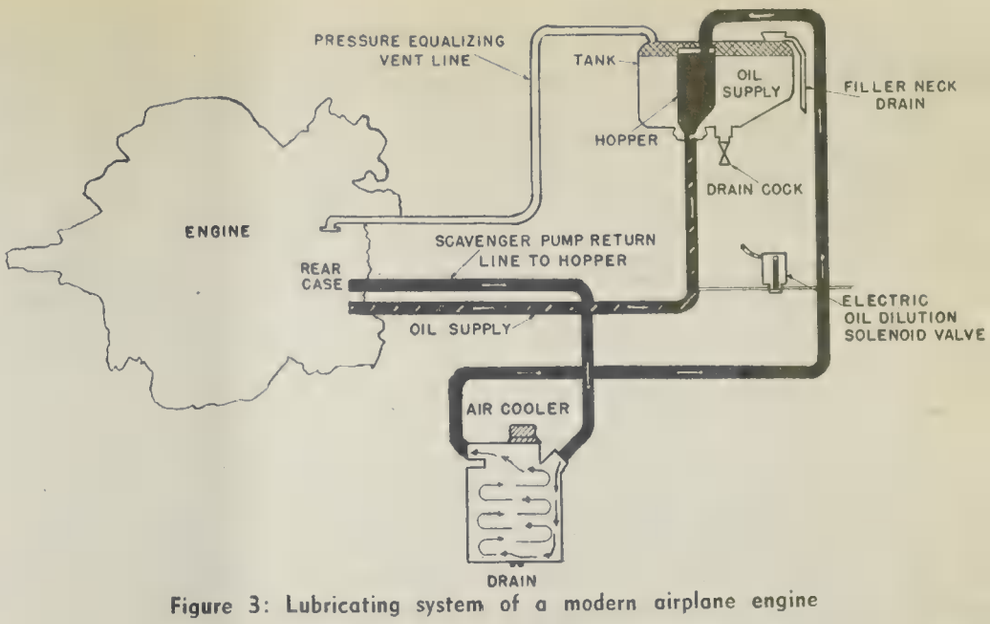


Figure 3: Lubricating system of a modern airplane engine

Figure 3 shows in outline the oiling system for a modern airplane engine. The oil tank, known as a "hopper tank," is actually two tanks with limited communication between them. The oil in active circulation is confined to the smaller interior tank but, as this is consumed, fresh oil flows in from the larger supply tank to replace it. This type of tank tends to prevent contamination of the main oil supply and also is very helpful in starting engines in cold weather. When a cold start is anticipated, a small amount of fuel is added to the oil just before the engine is stopped. This greatly reduces the viscosity of the oil and permits starting on what is practically a light-bodied oil. As the engine warms up, the added fuel evaporates so that, by the time full power for take-off is needed, the lubricating oil has regained most of its original viscosity and lubricating value.

OIL FOR COOLING—Oil from the tank is pumped through channels in the crank shaft and issues as a spray from the ends of the crank bearing. Sufficient oil is pumped to cool the pistons, rods, and other parts; this quantity, of course, is far in excess of that needed for lubrication. The oil is then collected in the crank case, picked up by a scavenging pump which passes it through a cooler, and then back to the tank. A 1000 horsepower engine normally circulates about 15 gallons of oil per minute but the amount in active circulation at any one time is only about five gallons. Oil consumption may amount to about 1.7 gallons per hour, so that the average life of the oil is approximately 500 trips through the engine before it finds its way past the piston rings or is lost elsewhere.

Oil entering the engine through ports in the crank shaft is subject to considerable centrifugal force before it is released at the crank bearing. Any insoluble material is apt to deposit in these ports and interfere with circulation. The most troublesome deposits come from the combustion products which tend to work down past the piston rings and are then picked up by the oil. A lightly refined oil is capable of holding these compounds in suspension fairly well but is also apt to form sludge and give generally poor results in other parts of the engine. More highly refined oils give cleaner engines but are less capable of holding the dense fuel residues in suspension, particularly before they have formed a slight amount of acidity

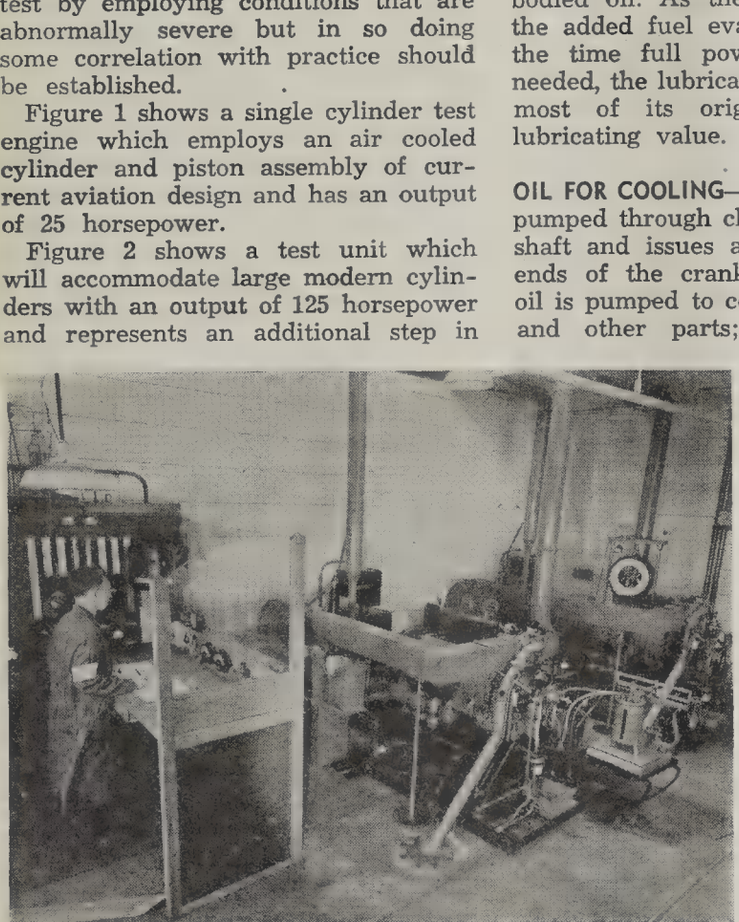


Figure 1: A single cylinder test engine of aviation design is used for preliminary screening of airplane engine oils

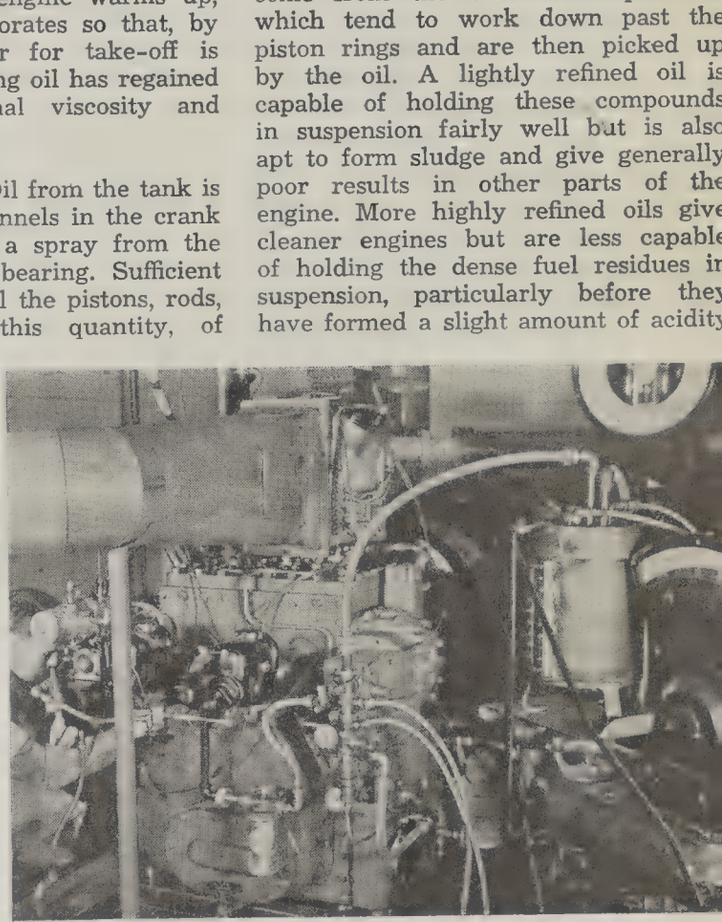


Figure 2: This testing unit with an output of 125 horsepower represents a further step in improving aviation lubricants

through oxidation. It is believed that these acids form soaps which have a detergent effect and prevent excessive deposits.

Considerable work has been done to reduce oxidation of the oil and several additives are effective in this direction. When these are used, the formation of acidity is suppressed and it may be necessary to introduce a detergent as well or choose an oxidation inhibitor with some detergent action in order to keep insoluble contaminants in suspension. It is important that an excessive build-up of acidity does not occur, because it may cause damage to the main connecting rod bearings. These usually contain lead or cadmium, which are both affected by petroleum acids if the concentration becomes too high. However, very effective additives for preventing bearing corrosion have been discovered and this problem is not likely to become difficult to control.

Oil is sprayed from the crank bearing more or less indiscriminately around the crank case to lubricate the pistons, connecting rods, and timing gears. Pistons and piston rings become very hot and are the most troublesome parts of the engine from a lubrication angle. Their reciprocating motion with periods of rest at the top and bottom of each stroke is not conducive to the maintenance of a fluid oil film such as obtains in a journal bearing under constant motion.

DECOMPOSITION—Lubrication at top stroke is especially difficult because hot gases from fuel combustion work in behind the rings, forcing them tightly against the cylinder wall; temperatures are so high that some decomposition of the oil cannot be avoided. If such decomposition leads to tar or dense carbon, it may cause the rings to stick tightly in their grooves, resulting in serious damage. Stuck rings are apt to break and to score cylinder walls and may pass enough hot combustion gases to overheat the piston, causing detonation and possible destruction of the engine. In the reduction of ring sticking and piston deposits, a great deal has already been accomplished by proper selection of crudes and the choice of proper refining methods. It seems probable, however, that further improvement can come only from the use of additives. Many research projects along this line are now under way and promising results are being obtained. The problem is a difficult one, however, and progress has been slow. Additives also help to reduce carbon formation on the underside of piston crowns which can interfere with effective cooling of the pistons. But careful selection is necessary to avoid excessive deposits in the combustion chamber and on exhaust valves.

Figure 4 shows airplane engine pistons operated on high-grade petroleum oil, and the same oil containing a small amount of an additive. A substantial improvement is evident both at the rings and under the piston crown but the better performance of oil containing the additive is even more significant when the difference in running time is taken into account. The test on straight petroleum oil was stopped at 13 hours because the top ring was stuck. This was ascertained by measurement of gas blow-by into the crank case. The additive oil showed no ring sticking at the end of the test period of 30 hours. This test was made exceptionally severe to simulate "take-off" conditions which in practice occur intermittently for only a few minutes while the airplane is leaving the ground. It is the most highly stressed period in airplane operation.

VERSATILITY—There are many other parts in a modern airplane engine where adequate lubrication must be maintained, but oils which suffice for the main and crank bearings, pistons, and rings are usually satisfactory elsewhere. Exception might be made in the case of reduction drive gears which transmit the entire output of the engine and are, therefore, heavily loaded. In some cases it has been found necessary to employ "oiliness" additives to withstand the high tooth pressures. Many agents of this type are known but the majority are of doubtful value for internal combustion engine lubricants because they lack stability at high temperatures or are not compatible with other additives which may be necessary. When dealing with additives, it is important to study not only compatibility of the various additives with each other but also with the oil to which they are added. An oil which gives superior performance without additives is not necessarily the best oil to use with them. This consideration makes the additive problem still more complicated.

In addition to the power plant, a large modern airplane contains a complex hydraulic control system which also must be lubricated. Generally, the same system also includes the mechanical stabilizer and brakes. In contrast to the engine, the control system, except the brakes, operates at low temperature and oxidation is not a factor. The oil must lubricate the pressure pumps, but its outstanding requirements are fluidity at very low temperatures, and it must not cause undue swelling of various synthetic rubber components of the hydraulic system. This requires as a starting point an oil of very low cold test or congealing point, as low as minus 70 or 80 degrees, Fahrenheit. Such oils can be obtained only from relatively light fractions of so-called naphthenic crudes but these oils cause excessive swelling of synthetic rubber. Swelling can largely be corrected by drastic refining by which compounds of an aromatic nature are removed from the oil. The completely saturated components that remain have little effect on synthetic rubbers now in use.

Drastic refining also improves the fluidity of the oil at low temperatures but, as the starting material is a naphthenic type oil, the desired combination of viscosity and fluidity cannot be obtained from the oil alone. Several V.I. improvers have been found which accomplish this but military secrecy prevents a detailed discussion of them.

Synthetic lubricants of non-petroleum origin have appeared from time to time but so far they have found only limited acceptance. Research on such lubricants is still continuing and synthetic oils may, at some future time, become a factor in aviation. When consideration is given to the enormous demand for aviation lubricants, now measured in thousands of barrels a day, the economics of producing such amounts synthetically become staggering. It seems likely, therefore, that petroleum will provide the major supply for some time to come.

The accomplishments of modern aviation have been achieved through the co-operative effort of many minds in many fields of engineering. The petroleum industry has been privileged to contribute to this effort and recognizes its responsibility toward still further accomplishment.



CHEAPER THIOPHENE

Will Have Many Uses In Chemical Industry

UNEXPLORED fields in chemistry—especially in the plastics, pharmaceutical, and dyestuffs industries—are expected to be opened up as a result of an inexpensive method for producing thiophene from petroleum.

Previously priced at $54.00 per pound—too expensive for extensive use—thiophene can now be produced by the Socony-Vacuum Oil Company at a cost estimated to make it commercially attractive. This is expected to have far-reaching results in many phases of industries using chemicals. For example, thiophene may alter the elasticity, brittleness, hardness, and other properties of plastics, the color of dyestuffs, and the physiological effects of medicinals. It is a colorless liquid, heavier than water, boiling at 183 degrees, Fahrenheit. Its odor resembles somewhat that of benzene.

Chemically, thiophene has the empirical formula C_4H_4S and contains 57.1 percent carbon, 4.8 percent hydrogen, and 38.1 percent sulphur. Its structure is agreed to consist of a five-membered ring containing four carbon atoms and one sulphur atom. The ring contains two double bonds between two of the pairs of carbon atoms. One hydrogen atom is connected to each carbon atom.

In its reactions thiophene resembles benzene, although different reaction conditions may be necessary. A large portion of the chemical industry is built around the chemistry of benzene. Dyes, pharmaceuticals, plastics, and a host of other chemical commodities to a large extent are derived from benzene and its compounds. Thiophene, therefore, permits the chemist to prepare many of these products which differ in that they will contain the thiophene ring in place of the conventional six-carbon atom-benzene ring.

Soft Dies . . . Hard Jobs

Developed Originally by the Aircraft Industry to Improve Design Flexibility, Speed Production, and Lower Die Cost for Short-Run Work, the Use of Zinc Alloy Dies for Sheet-Metal Forming has Established Itself as Permanent Tooling and is Invading Other Fields as Well

WHEN harking back to the dim days before war production really started, some awkward or tedious production methods can all too vividly be recalled. In the aircraft industry, for example, mass-production techniques were hardly necessary, with planes usually ordered in lots of one to ten and early delivery seldom a requirement. With such small lots, sheet-metal parts were usually shaped by hand over wooden forms or stamped out on rope drop hammers using low-purity zinc dies and lead-antimony punches.

Today, however, automotive manufacturing methods are applied or even improved upon to meet the high-production requirements of aviation. The advantages of the soft metal die are retained through the use of a specially developed zinc alloy, called Kirksite "A", produced by National Lead Company, which has more durability than straight zinc. More and more aircraft sheet metal forming and blanking has been transferred from drop hammers to punch presses and hydraulic presses. And the soft metal dies have turned out to be such good permanent tooling that other industries are seeking to apply the secret of their successful use.

Some advantages of zinc alloy dies over steel dies are as follows:

The zinc-base dies are much less expensive. Steel dies are competitively uneconomical for relatively short-run work because the combination of their higher cost and the small-lot jobs results in a very high tool-cost per part. Obviously, the shorter the production run the more important becomes the die cost per unit produced, so that cheaper dies are increasingly attractive.

Although the zinc alloy in ingot form costs more than the steel or cast iron in raw-material form, the cost of the finished die is much less for the Kirksite. Labor to make the die, machining costs, and so on are low enough for the zinc-alloy dies to make them cheaper *to produce* than steel or iron dies. What eventually controls the economy of the application is the number of parts to be made with a given die.

The zinc alloy dies can be produced in a matter of hours, as against days for steel dies. This means that production of a part can be started sooner, or that frequent changes in design or experimental production can be accomplished without prohibitive delays. In the reconversion, retooling, and product-experimenting period that lies just ahead, this last may loom as a major factor in smart research-engineering. Also, minor changes can be made directly on the zinc alloy dies with a welding torch, when such changes are indicated by design modifications or for experimental reasons.

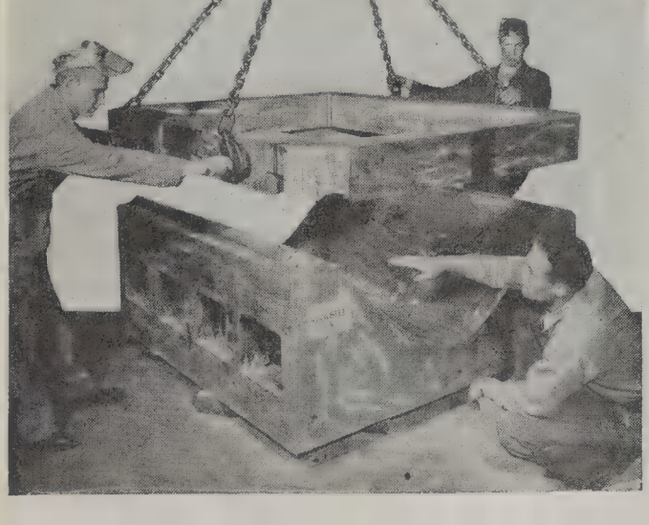
The skilled but scarce diemakers required for making steel dies (blanking dies, for example) are not needed in the manufacture of zinc alloy dies, nor is as much critical machining required to finish the cast dies to close dimensional tolerances.

Other advantages of importance are:

The accuracy of casting that is possible with zinc alloys, often obviating machining of the cast die; the elimination of die scratches on the work by virtue of the zinc alloy's softness; and the reclamation value of the zinc alloy, for it is almost 100 percent reusable by simply remelting under proper conditions.



Stampings for fuel tanks which can be dropped from airplanes when empty are pressed out of S.A.E. 1010 steel on Kirksite dies by a 1500-ton double-acting press shown in the rear



Two thirds of the weight of this huge die was eliminated by correct coring. It was made for use in the Douglas Aircraft Santa Monica plant

VERSATILITY—The zinc-alloy dies are made either as sand castings, plaster-mold castings, or rolled sheet, depending on the purpose. Most soft alloy stamping, forming, and drawing dies are cast, usually in sand; dies for certain plastics molding operations—a growing use for Kirksite—are cast in plaster molds, as are some stamping dies; dies made from rolled zinc alloy sheets are used for many blanking, forming, and trimming jobs.

The forming machinery on which the

zinc-alloy dies can be and are being used includes rope and air drop hammers, hydraulic presses and brakes, and mechanical presses of toggle, crank, and double-acting types. They are used with or without pressure rings or binders made either of the zinc-alloy die material or of iron. The use of Kirksite "A" dies for punch press operations is one of the most recent developments, of which more later.

Punches used with cast zinc-alloy dies may be made of the zinc alloy itself, of antimonial lead, of cast plastic, of hydrolized woods like Masonite, or of rubber. Often the punch is made by casting the punch material into the cavity of the Kirksite die. Rolled Kirksite dies for blanking are used in conjunction wth steel punches, the clearance between die and punch being *zero*, so that the die will "flow" toward the punch and keep the cutting edge honed and self-healing.

Although care must be taken in the production of sand-cast, zinc-alloy dies to reproduce accurately the dimensions, configuration, and detail of the model, the hand and machine labor required for this is much less than for steel dies and, indeed, less than for any other durable die material. The first step is the production of an accurate pattern. Patterns may be either wood or plaster, the latter being cheaper and more speedily made. The aircraft industry generally uses plaster patterns, which are made from die drawings by the "loft template" method.

The molds in which the dies are cast are of the "open" type—that is, the top of the casting is open to the atmosphere—since the "closed" mold familiar to foundrymen does not produce dies as sound and smooth, especially in heavy sections. Any high-grade molding sand of fine texture may be used, with little or no binder required.

For melting the zinc alloy (it melts at 717 degrees, Fahrenheit) special cast iron kettles or pots are used. Welded steel kettles are attacked rapidly by the zinc alloy and are therefore not used. A protective coating is applied to the iron kettles to provide additional resistance to attack. Kettles are either gas-, oil-, or coke-fired, with gas the most popular. Electric furnaces can be used but generally are not.

OPERATION	MATERIAL	GAGE	SHAPE	NO. OF PARTS OR BLANKS
FORMING	Armor plate	¼ in.	2-ft. spher. radius	several hundred
	Stainless steel	0.091 in.	2.5 in. rect. cup	400
	Stainless steel	0.038 in.	X-exhaust manifold	2800
	Body stock steel	0.089 in.	3-in. draw	1200
	Body stock steel	0.037 in.	3-in. bends	18,000
BLANKING	Stainless steel	up to 0.050 in.	———	100
	Body stock steel	0.062 in.	———	1800
	Duralumin	0.032 in.	———	30,000
	Formica	0.062 in.	———	10,000

Condensed tabulation of some successful applications of zinc-alloy dies

RECLAMATION—Melting of new ingot or clean uncontaminated old dies is accomplished without flux and with very low dressing. Borings or finely divided scrap must be fluxed in remelting (with sal ammoniac and zinc chloride) to remove undesirable dirt and oxides.

The most important metallurgical precaution to be observed in melting Kirksite "A" is that contamination by lead and tin must be avoided. One half of 1 percent of lead will reduce the tensile strength 30 percent and the impact strength 75 percent in one year of normal aging, and will also cause the dies to expand ⅛ inch per foot in the same period. More than ¼ percent iron is also harmful, causing surface defects in use, known as "dural-bug marks."

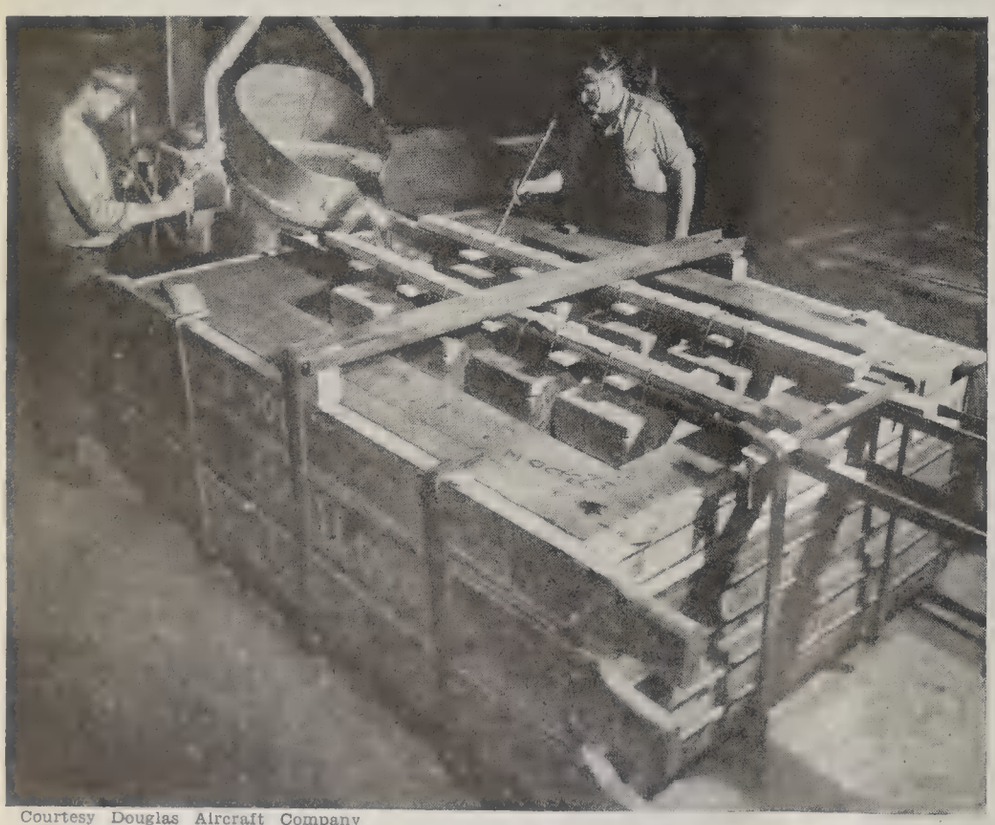
If the pattern and foundry work are properly done, little fitting is required to match the punch to the die and the pressure ring (when used). No die-polishing is needed if the die is to make steel, stainless steel, or Inconel (nickel-chromium-iron alloy) stampings, as the hard sheets being formed polish the die. Dies for aluminum are either polished, or used to make a few stampings out of sheet steel to smooth the die surfaces before running on aluminum.

For small dies greater accuracy and better surface finish are obtained by casting the Kirksite "A" in plaster molds. Special plasters and mixers are used. Patterns may be of wood, metal, or plaster itself, and a parting compound of some type must be used.

LOW COST—Broadly speaking, the zinc-alloy dies are regarded as low-cost dies useful for moderate production runs. They cannot be expected to replace steel or cast iron dies in all or even most of their established applications. The accompanying table indicates some successful Kirksite "A" applications and the number of parts either involved in the lot or the number made before die failure. These are all of an "extreme" nature, showing either the thickest gages, or the longest runs made with zinc-alloy dies. It has occasionally been found more economical to use up several zinc alloy dies on one job than to employ one steel die for the whole order.

The current trends in the use of Kirksite dies hold much significance for industry in general. Most important perhaps is the growing use of zinc-alloy dies for forming and drawing ordinary steel. This opens up possibilities of using Kirksite in the automobile and general stamping industries. In one case, 25,000 of the jettison or droppable fuel tanks for the P-38's have been stamped on an 800-ton double-acting press out of 0.024-inch steel, using one Kirksite die set.

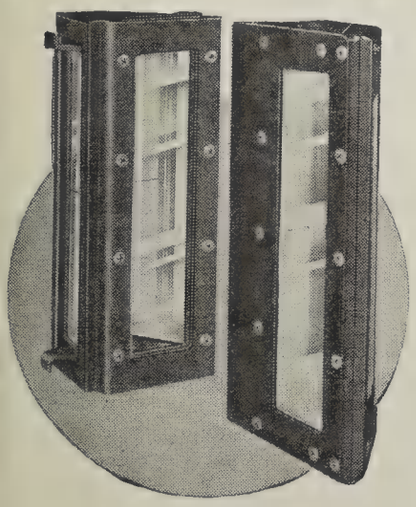
In another instance, a three-piece zinc alloy die set produced 7500 automotive engine valve cover plates out of 0.078-inch cold rolled steel. The total cost of the die set, including patterns, metal, castings, and machining was only 32 percent of the cost of conventional dies. In addition, the Kirksite die set required 48 man-hours of labor as against 69 man-days for the usual dies.



Courtesy Douglas Aircraft Company

Workmen pour Kirksite to form a male punch for a triple action hydro-press die. This picture shows how a large Kirksite casting is cored in order to reduce weight

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1004-S	2 Reducing Lenses	1.20
3001-S	Lens Surface Prism	2.00 each
503-S	No. 1 Sable Hair Lettering brush	1.00 Dozen
3021-S	Amici Roof Prism (3rd grade)	.25 each
4009-S	Heat Absorbing Glass 4"x5".	.35 each
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6094-S	16	75	Cemented	$1.00
6021-S	18	49	Cemented	60c
6023-S	25	95	Cemented	75c
6066-S	32	132	Uncemented	75c

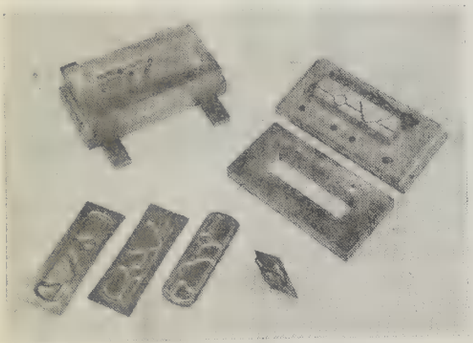
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A new development that holds great promise for the economical production of dies for heavy steel stampings is the application of a hardened steel armor over the surface of a cast Kirksite "A" die set. Another method of increasing the hardness and life of the dies (especially in certain areas such as draw edges or for corner re-enforcement when forming heavy steel) is to cast



Courtesy White Motor Company

Used for stamping out engine valve covers, this Kirksite "A" die cost about 30 percent less than a similar steel die, and is reported to be still serviceable after stamping 7500 pieces from .078 inch steel

steel inserts in the die, using well-developed anchoring methods.

A second important development is the increasing use of blanking dies made from rolled Kirksite sheet. Some of the successful applications of this type are definitely in the long-run field and all are considered "permanent tooling" by their users. A few plants even mass-produce the dies, one company in particular having a line-production setup for making Kirksite blanking dies at the rate of 1000 a month.

A third important application that will certainly carry zinc-alloy dies far beyond the confines of aircraft manufacturing is their use for molding plastics and rubber. Kirksite molds for both compression and injection molding are now used in several plants, with mold-life results varying from job to job.

LONG RUNS—For example, one company has produced 600,000 injection-molded plastics telescope rings from a four-cavity die made entirely of zinc alloy except for sprue puller and stripper plate. The parts are molded under 16,000 pounds pressure at 350 degrees, Fahrenheit, and 50,000 pounds clamping pressure.

Another manufacturer made an extensive study of Kirksite dies for high-pressure transfer molding of phenol formaldehyde, urea formaldehyde, and phenol furfural molding compounds and for compression molding of laminated plastics. The zinc alloy molds were found to work satisfactorily; hobbing was more difficult than with steel molds, for the cast Kirksite "A" lacks the ductility of steel, but the Kirksite was much cheaper and has the unique property of not sticking to the molded plastics part.

Other "tooling" uses for this zinc alloy that are not exclusively aeronautical include form blocks for deep drawing on hydraulic presses; stretch press dies; chuck jaws cast in permanent molds, which reduce both time and expense and last indefinitely; anti-chatter pads for milling operations; sand-cast tube-bending dies that save costly machining operations; heated dies for forming magnesium alloy sheet at 300 to 450 degrees, Fahrenheit; jigs and fixtures for assembly purposes.

The aircraft industry therefore must be thanked for having developed a type of low-cost tooling that is certain to be a boon to many other fields after the war. Now considered as full-run or permanent tooling for the stamping requirements of virtually all airplane plants, zinc-alloy dies can be similarly applied in making parts for expensive or custom-made automobiles, housings for oil burners, vending machines, special business machines, metal furniture, certain cooking utensils, lighting fixtures, and so on.

As "temporary tooling," they will also invade many other fields as well. To these they will bring design flexibility because of their low cost and the permissible rapid production of trial dies. Customer reaction to experimental designs can be obtained without building costly steel tools to produce them.

All of which is another way of describing zinc-alloy dies as a highly useful and a flexible adjunct to post-war product planning and reconversion, as well as a promising type of permanent tooling for longer-run work.

⊕ ⊕ ⊕

SOLDERING CANS

Now Accomplished With Tin-Lead Solder

IN SOLDERING the side seams of cans at high speed, a 5 percent tin-lead solder has largely supplanted the silver-lead solders developed for this purpose to save tin a few years ago. Since the 2 percent silver-lead solders quickly picked up about 5 percent tin from the tinned cans, this change in omitting the silver has not materially increased tin consumption for this purpose.

METAL ROLLING

Improved by Development of Two New Processes

TWO RECENT developments now arousing much interest among rolling-mill men also hold considerable potential significance for providing industry with better-quality rolled steel and non-ferrous products than previously available.

The first, the "Unitemper" mill, has received much attention from the tin-plate producing companies for temper passing. Instead of conventionally cold working the sheet between pressure rolls, the Unitemper mill continuously stretches the stock beyond its yield point between two sets of gripper rolls.

This process increases roll life and eliminates much of the bearing and rolling friction of pressure rolling. Hence it bids fair to lower operating costs. The sheet produced by the Unitemper mill has a more uniform degree of cold work throughout its section, while the conventional pressure-rolled sheet has a greater degree of cold work in the surface layers.

The second, the Krause mill, has aroused interest in ferrous and non-ferrous fields since it reduces a 26-inch wide strip from ½ inch to 0.030 inch in a single pass. This reduction is accomplished by holding the stock in tension with a gripper while four-inch diameter rolls are moved over it by frictional contact between the stock and reciprocating cam plates. Pressure is applied only on the work stroke, and the reduction is made largely through the tension in the strip.

Metal from this mill shows a finer and more even grain structure, and edge cracking in copper has been minimized. The relatively slow delivery speed of 30 feet per minute is offset by the reduction being accomplished in one pass. Developments are in progress toward making the operation continuous by welding the bars end to end.

MORE THE MERRIER

Many Ingredients Blended To Make Fine Steel

THE ERA of "just a few" alloying agents in a material is passing, and the common alloy of the future will have many ingredients, all there for a purpose. Aluminum, magnesium, lead, and zinc alloys are good nonferrous examples and the NE steels are outstanding as a ferrous case-in-point with "impurities" and tiny amounts of such things as boron, zirconium, vanadium, zinc, calcium, titanium, and so on functioning as alloying elements. A little of this and a little of that may not seem as inefficient some day as it once did.

BETTER BELLS

Arise from War-Time Need To Save Scarce Tin

AN INTERESTING change in the nature of so-called "aid to navigation" bells, necessitated by war-time shortages, will radically change bell metallurgy post-war. These navigation bells are made by the United States Coast Guard and are used by the navies of all the United Nations. Weighing from 225 to 1000 pounds, the bells were formerly made of a 20 percent tin bronze. To save tin the Coast Guard in 1942 began making bells of silicon bronze containing negligible amounts of tin. Not only did the new composition save 200 pounds of tin per 1000-pound bell, but it also reduced the cost of the bells about 10 cents per pound.

The silicon bronze bells ring in C sharp concert pitch instead of the conventional D of the tin bronze bell metal. One of the most important improvements is an increase in tensile strength from 28,000 pounds per square inch for the old bell metal to 45,000 pounds per square inch for the new. The new bells have not been known to crack, whereas the old bells had a high failure rate.

IT'S UP TO YOU TO HELP MAKE 2=3 WITH...



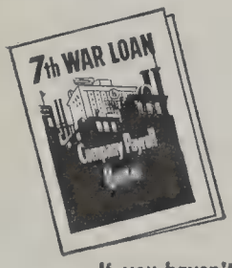
A job for seasoned executives—this 7th War Loan! Especially when we've got to make 2 war loans total just about as much as all 3 in 1944! Putting this over demands the combined and *continued* efforts of the "No. 1" men of American industry.

This means marshaling your plant drive to make every payday—from now 'til June 30th—do its share toward the success of the 7th. Directing the drive is not enough. It's equally important to check to see that your directions are being carried out—intelligently!

For example, has every employee had:

1. an opportunity to see the new Treasury film, "Mr. and Mrs. America"?
2. a copy of "How To Get There," the new Finance Division booklet?
3. a new bond-holding envelope with explanation of its convenience?
4. 7th War Loan posters prominently displayed in his or her department?
5. information on the department quota—and an urgent personal solicitation to do his or her share?

Remember, meeting—and beating—your highest-yet 7th War Loan quota is a task calling for "No. 1" executive ability. Your full cooperation is needed to make a fine showing in the 7th! Do not hesitate to ask your local War Finance Chairman for any desired aid. It will be gladly and promptly given.



If you haven't a copy of this important booklet, "7th War Loan Company Quotas," get in touch immediately with your local War Finance Chairman.

The Treasury Department acknowledges with appreciation the publication of this message by

SCIENTIFIC AMERICAN

★ *This is an official U. S. Treasury advertisement prepared under the auspices of Treasury Department and War Advertising Council* ★

Better Television

Plastics Mirrors and Lenses Have Overcome Many of the Difficulties of Working Large Glass Surfaces. Combined With High-Voltage Cathode-Ray Tubes, These Plastics Parts Make Possible Post-War Television Receivers that Produce Large Pictures Free from Interference

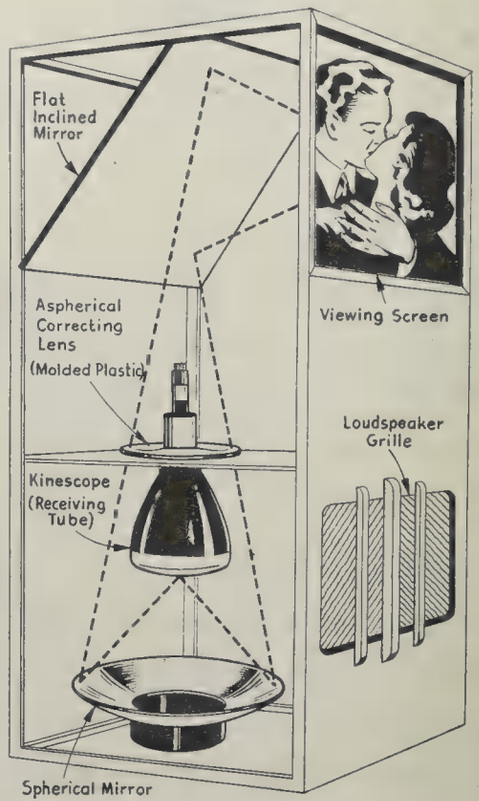
DEVELOPMENT of a television receiver capable of reproducing pictures that are brighter, clearer, and five times larger than were obtainable on pre-war sets has set a standard for what may be expected of this rapidly advancing art in the near future. This new Radio Corporation of America receiver features a new type of screen, 16 by 21 1/3 inches, made of surface-treated plastics.

Console models, containing projection-type television, FM, and standard broadcast receiving facilities, will cost approximately $395 when they can be put into production. RCA Victor will also have several models equipped with direct viewing picture tubes, and at least one table model priced at about $150.

TECHNICAL ADVANCES—The large-screen television receiver was made possible by four pre-war technical developments: (1) A reflective optical system which collects from the image on the receiving tube and projects upon the viewing screen about six times as much light as could be delivered from tube to screen by a conventional *F*/2 movie projection lens, without loss in image quality. (2) A built-in translucent plastics viewing screen with molded surfaces designed for even distribution of light over the area of the screen and distribution of transmitted light within the normal viewing angle. (3) An automatic frequency control system which virtually eliminates picture distortion caused by interference from automobile ignition and other noise impulses. (4) A new high-voltage type of cathode-ray tube which produces a brilliant initial image.

MIRROR AND LENS—The optical system, which was developed by RCA Laboratories engineers before the war, consists primarily of a spherical front surface mirror and an aspherical correcting lens. The mirror may be visualized as a shallow bowl, with its reflective coating on the concave surface facing the light source. The lens is flat on one side, with the opposite surface rising slightly at the center and at the edges, but depressed in the intermediate area.

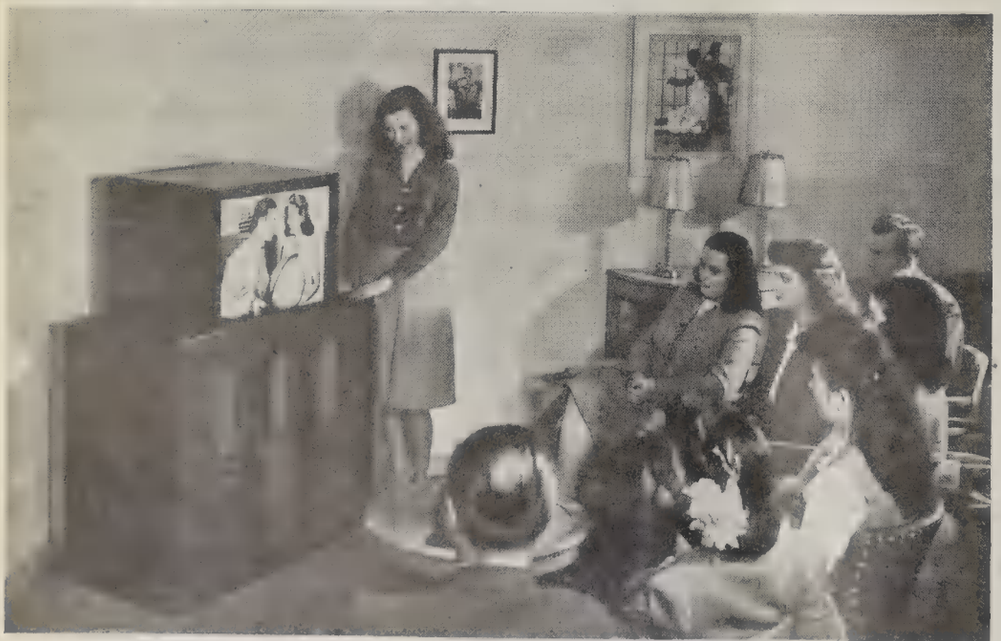
The system is mounted with the image end of the receiving tube facing downward through an opening in the center of the lens and facing the center of the mirror. Images appearing on the face of the tube are picked up by the mirror and reflected through the aspherical lens to the back of the viewing screen.



Simplified diagram of a large-screen television receiver for the home. The broken lines trace the path of light from a single picture element on the face of the cathode-ray tube to a corresponding point on the screen

The great light-gathering power of this optical system makes it possible to transfer to the viewing screen a large percentage of the light produced on the face of the tube, whereas the efficiency of a conventional projection lens in such an application is extremely low. The function of the aspherical lens is to bring the light reflected by the mirror to a sharp focus on the screen. A major obstacle to the development of the system was the time and cost involved in making aspherical lenses from glass. The problem was solved by devising methods and equipment for molding the lenses from a transparent plastics material.

THE VIEWING SCREEN—Two different optical problems have been overcome by special features of the new translucent viewing screen. One was a tendency which the screen would normally have to develop a "hot spot," resulting in a glare in the center and insufficient light in other parts of the image. The other was the need for distributing a major portion of the trans-



Latest design in large-screen home television receiving equipment

mitted light to the area which the spectators would occupy in relation to the receiver. Solutions were found in a combination of principles which have been incorporated in the molded design of the screen.

PICTURE CONTROL—Automatic frequency control discriminates between the transmitted synchronizing impulse and any stray noise impulse, which otherwise might trigger the controlling picture sawtooth wave voltage prematurely. This discrimination is achieved by fixing a time interval for the former and shutting out impulses which do not arrive on schedule.

Without some such control, noise interference could throw the scanning beam in the receiver out of synchronization with the one in the transmitter, causing the former to "black out" and return on some lines of the picture before they were completed. "Tear outs" and ragged edge effects would result. Preventing this form of distortion, the new system regulates reception in somewhat the same way that a fly-wheel regulates machinery.

NEW TUBES—The high-voltage cathode-ray tube used in the large-screen home television receiver is substantially smaller and lighter in weight than pre-war direct-viewing picture tubes. This means smaller, lighter, and less costly home receivers, and may mean lower tube replacement costs.

Designed to operate at a rated voltage of 27,000 volts—nearly four times the voltage used in pre-war picture tubes—the new tubes produce a much brighter initial image. This high initial brilliance, in conjunction with the efficiency of the optical system, makes it possible to obtain from a tube with a face diameter of only five inches a bright, clear image on a screen that is more than five times as large as could be produced on a pre-war direct-viewing tube with a face diameter of 12 inches.

⊕ ⊕ ⊕

SHOP PRACTICE

Can Reduce Unit Cost of Production

With post-war industrial competition certain to change the emphasis from production at almost any cost to a peace-time policy of profits through production economies instead of higher prices, future factory management will require every effort to reduce unit costs, Professor George W. Barnwell told the Metropolitan Section of The American Society of Mechanical Engineers recently. Mr. Barnwell is professor of production practice and director of shops at Stevens Institute of Technology.

"After the war and the rush to buy many things which we have had to do without for the past several years, manufacturers are going to find themselves up against the old competition that is ever present in our way of life," the speaker declared.

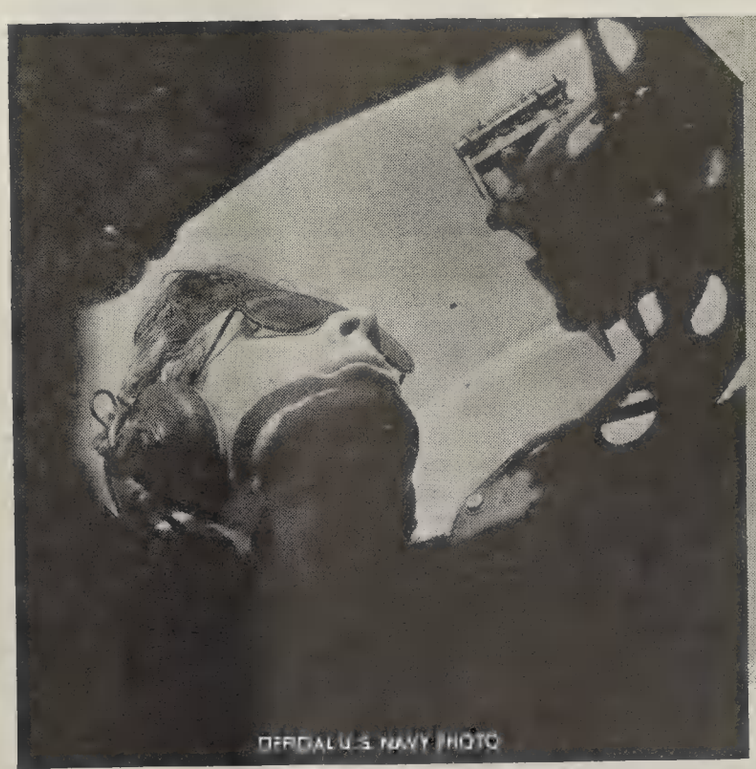
Under these circumstances, the manufacturer has three possible solutions, he continued: To lift selling prices while maintaining present volume; to increase volume at the same selling prices and, most desirable of the three, to cut the unit cost of production.

"The cost of producing many products actually has been reduced by a change of material, design, or method of processing, even in the war period," Professor Barnwell said. "Huge expenditures for plant, equipment, special tools, jigs, and fixtures, and the like have resulted in lower net cost per unit of output, but there are, in addition, other points at which an attack may be made on this problem in order to cope with the difficulties of post-war competition."

Such efforts at reducing unit costs, the speaker continued, may well stem from the machine shop itself, where proper shop organization will be found to be the starting point of all efficiency.

"As a means to this end, it is well to assign authority and responsibility to workers in equal amounts, since a matter that is anybody's business usually develops into a matter which is nobody's business," Professor Barnwell said.

Additional vital elements in shop practice to assure the lowest possible unit costs, the speaker said, include the following: Coördination of the engineering or design department with the



Ray-Bans IN WAR SERVICE

Spotting the Enemy with RAY-BANS

In the top turret of a U. S. Navy Liberator this gunner spends hours upon hours of patrol duty—scanning the brilliant sky for enemy planes, while his crew mates search for submarines and surface craft. Ray-Ban Sun Glasses protect flyers' vision with cool, comfortable scientifically designed lenses and frames. Before the war, you saw Ray-Bans everywhere—at shooting ranges, at lake resorts, on the city streets. Today thousands of pairs of Ray-Bans are in use on the war fronts—protecting precious eyesight from punishing sun glare.





Shown are the distinctive Ray-Ban Sun Glasses and Ray-Ban Shooting Glasses. All Ray-Ban Sun Glass production is allocated to military use.

BAUSCH & LOMB OPTICAL CO., ROCHESTER 2, N.Y.

BAUSCH & LOMB IS DESIGNER AND PRODUCER OF BINOCULARS, SPOTTING SCOPES, RAY-BAN SUN GLASSES, AND A COMPLETE LINE OF OPTICAL INSTRUMENTS

shop production department; proper selection of equipment and small tools on a "use cost" basis rather than a first cost basis; control of materials and tools by such means as determining minimum amounts needed and minimum economical amounts to be ordered; provision for adequate inventories and for tool repairs; consideration of problems of shop layout with recognition of the economy of short moves, importance of wide aisles, and a layout emphasizing the relative cost importance of product and process.

BATTLE RATIONS

Now Being Wrapped In Laminated Paper

K RATION meals for GIs at the battlefronts are now being wrapped in a special heat-sealed moisture-proof material. Heretofore the heavy cardboard box containing K rations was given a protective coating by dipping it in wax, but the Army's Quartermaster Department found the wax often cracked in shipment and so they ordered new specifications.

The new wrapping material, made of two thicknesses of waxed paper laminated over an inner layer of foil, was developed by the Marathon Paper Company. The Package Machinery Company has re-designed parts of its standard wrapping machine to handle the material. Six of these machines will go to the American Chicle Company, and three to the Cracker Jack Company. Each will have an expected capacity of 80 K ration cartons per minute.

TURBO-ELECTRIC POWER

Will Drive New Coal-Fired Locomotives

THREE coal-burning locomotives designed to use in combination the best features of steam, turbine, and electric drive are planned for future construction. Each of these new locomotives will combine in a single self-contained independent unit the advantages of speed, continuous power, and smoothness of operation that, with other types of fuel and comparable horsepower, have heretofore been achieved only in multiple units—two or more complete engines connected together.

This new kind of locomotive will convert the heat energy of coal and steam into 6000 horsepower, delivered from a turbine to generators for the electric motors which drive the wheels. It will be capable of running more than 100 miles an hour under full load, with high sustained speeds on grades.

The basic designs for the new motive power have been completed by the Baldwin Locomotive Works in collaboration with engineers of the Chesapeake and Ohio Railroad, for which the engines will be constructed. The



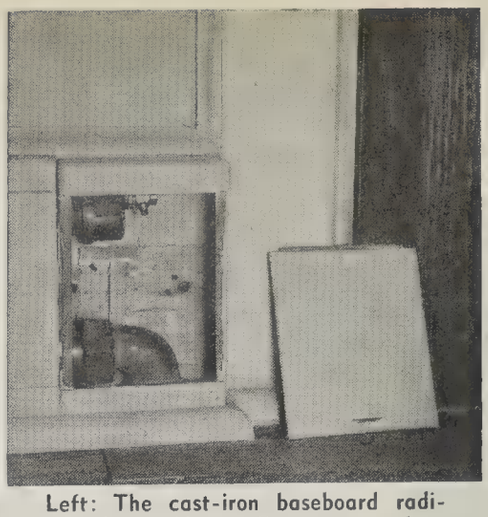
steam turbine and electrical equipment required by the railroad as integral features have been designed and will be built by Westinghouse. In horsepower per self-contained power unit this turbine-electric locomotive is expected to surpass by two to three times the most powerful Diesel locomotive yet built.

The cab will be near the front end of the locomotive, giving the engineer a protected location with excellent forward vision. The coal supply will be carried at the head end of the locomotive instead of in the tender, as at present. The boiler will take up the center section behind the engineer's cab. The steam turbine and electric generators will be placed at the rear and will feed 4000 kilowatts of electricity—enough for all of the electric power needs of a town of 5000 population—through motors mounted on each of the driving wheels.

BASEBOARD HEATERS

Keep Temperature Steadier Than Older Methods

INVISIBLE home heating, with neither conventional radiators nor registers in a room and known as the "radiant baseboard," has several advantages over conventional heating arrange-



Left: The cast-iron baseboard radiates heat. Above: Cover removed to show pipe connections and vent valve

ments. Room warmth comes from a hollow cast-iron baseboard supplied with hot water from a regular home heating boiler. Radiant baseboards replaced wooden baseboards along the bottom of outside walls in rooms of the research home of the Institute of Boiler and Radiator Manufacturers during the severe past winter and proved completely successful.

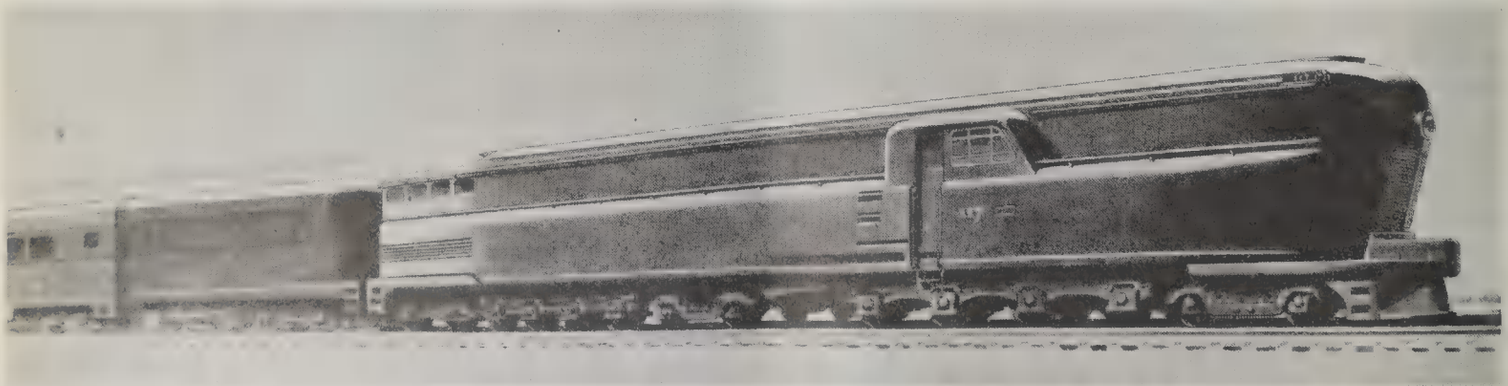
The radiant baseboards are painted to match woodwork of the room and are hard to distinguish from the trim which they replaced. Pipe connections from the boiler are concealed in boxes at the ends of the baseboards. Installation is a relatively simple job.

The baseboard in the research home, located at the University of Illinois, is slightly over six inches high and less than two inches wide, though appearing thinner because of molding at top and bottom. Future installations may be recessed into the wall and extend into the room no more than an average wooden baseboard.

As a heat source the radiant baseboard is completely inconspicuous, and does not in any way interfere with furniture arrangement or room use, as radiators or registers sometimes do. It is as easy to keep clean as any conventional baseboard.

By spreading its warmth in the coolest part of the room—the bottom of the outside wall—and providing a room-long source of heat, the radiant baseboard provides the most uniform floor-to-ceiling home temperatures ever achieved.

In previous years, with conventional radiators as heat sources, the floor-to-ceiling temperature difference in the research home was five degrees in zero



Many advantages, including smoothness of operation, are claimed for steam turbo-electric locomotives

weather. This past winter, with baseboard heat, the difference was never more than three degrees, even when the mercury outdoors dropped to subzero levels. How effectively the radiant baseboard concentrates heat in the lower part of the room is shown by the fact that, with the new heat distribution system, temperatures in the research home are uniform from the five-foot level to the eight-foot ceiling—the area which ordinarily is increasingly the hottest in a room.

CRITICAL METALS

Post-War Production Here is Urged for National Safety

CONTINUED production in the post-war period of certain metals vital to national safety, even though their importation would be cheaper, is urged by Dr. William H. Waggaman, mineral technologist of the United States Bureau of Mines.

Richly endowed in most minerals, this country nevertheless lacks some, and has only medium or low-grade deposits of others, such as manganese, chromium, and tungsten. These deposits, more expensive to mine, are being worked under war emergency conditions, Dr. Waggaman says in "Chemical and Engineering News," American Chemical Society publication.

After the war, he points out, it would be cheaper to import ores of higher grade which other countries can produce at less cost, and shut down many American mines and processing plants producing these highly important minerals. But "through extensive explorations we have established substantial reserves of certain low-grade domestic ores; by intensive research investigations we have learned how they may be concentrated or the desired ingredients extracted at a cost that offsets, in part at least, the advantages heretofore offered by higher-grade ores from foreign sources; men have been trained to mine, mill, and process these domestic raw materials, and continued research and improved techniques should lower production costs still further.

"It seems logical therefore to continue to utilize these resources to provide jobs for our people and maximum insurance against a catastrophe such as now engulfs so many nations unprepared for war. Certainly, no policy that jeopardizes this nation's security is either economical or wise."

JET TURBINES

Have Extremely Low Oil Consumption Ratings

HOW TO heat, not cool, lubricating oil used in the jet-plane power plant developed by General Electric engineers was one of the problems solved by them in their work.

Heating was necessary because there is only one major moving part in the unit. This rotates without appreciable vibration and hence can be supported on anti-friction bearings.

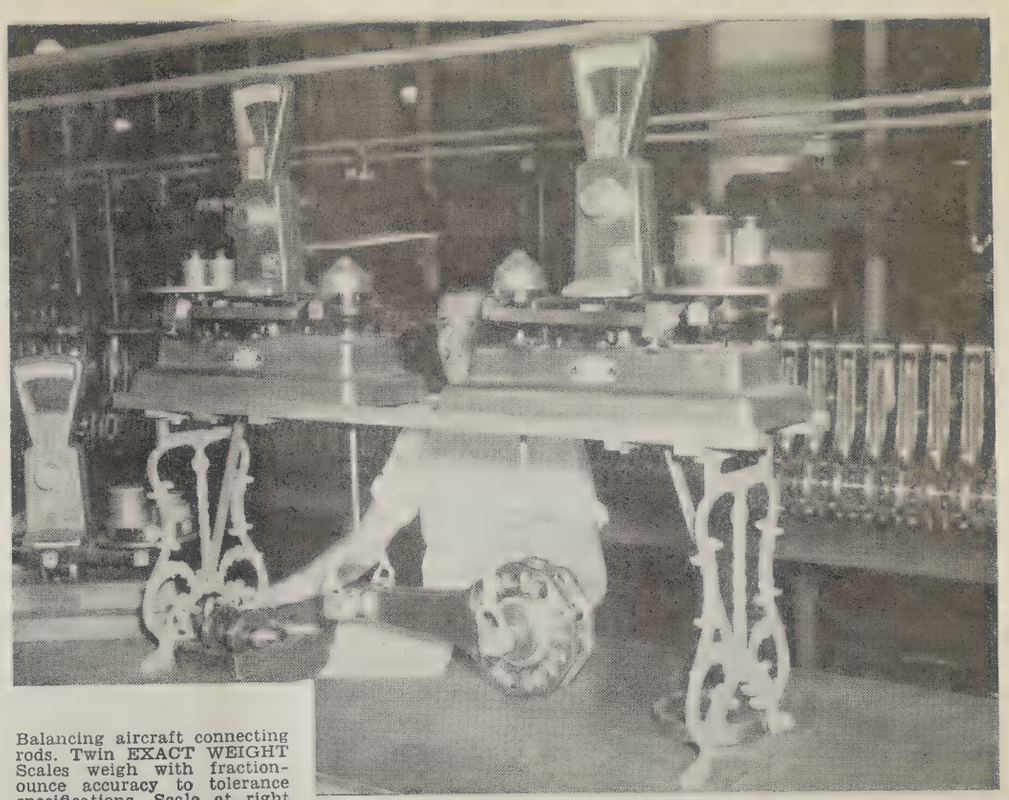
As a result, heat rejection to the oil is very low. An oil heating system with thermostat control was devised to maintain the oil at proper temperature under varying degrees of cold at high altitudes.

Oil consumption is negligible, and the amount of lubricating oil required by the jet-propulsion gas turbines is, therefore, small—being 15 percent less than that required in other aircraft power-plants. The entire lubricating system is integral with the gas-turbine engine, and no complex cooling mechanisms, oil coolers, or large oil tanks are involved.

Likewise, cooling the gas-turbine engine itself is a simple matter, and is provided for as an integral part of the design. Moreover, air required for cooling the unit is as little as 2 percent of the sum total taken in for operation.

Engineers who have worked on the jet turbines point out that inherent simplicity features such as these greatly facilitate production and operation. The power plant is a "packaged" unit which is installed easily. Inasmuch as it operates without appreciable vibration it can be tied right to the airframe. Operation-wise, relatively few gages and instruments face the pilot in the cockpit, and there are no propeller or fuel mixture controls.

The gas turbine engines will burn kerosine, automobile gasoline, or aviation high-test without any major changes being required. Since combustion is continuous, expensive high-octane fuels are not needed, and cheaper fuels are preferred.



Balancing aircraft connecting rods. Twin EXACT WEIGHT Scales weigh with fraction-ounce accuracy to tolerance specifications. Scale at right handles the heavy end, scale at left the light end, all in one operation.

Axing the Axis....

A man does not fell a tree with one blow. It takes many blows . . . chip, chip, chip at a time. Air power is the same. Not one plane but many planes . . . not one raid but many raids are needed to Axe the Axis. These planes are assembled from millions of parts, machined parts, most of them controlled, tested and checked with precision tools by skilled craftsmen. High on the list of precision equipment in the use of aircraft manufacture are scales. They do many operations of which balancing connecting rods is a vital one. We are proud indeed that EXACT WEIGHT Scales are in constant use for this and many other necessary operations throughout the aviation industry. Even though we are at home, far from the active war theatres, we supply many a precision instrument with which to AXE the AXIS. Engineers with difficult problems consult us daily. Join them!

INDUSTRIAL PRECISION

Exact Weight Scales

THE EXACT WEIGHT SCALE COMPANY

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New Products and Processes

COOLANT COOLING

Packaged Unit Speeds Production

A DEVELOPMENT brought about by the demand for maximum production from machine tools is the perfection of a system for controlling the temperature of coolants and cutting oils. Increased speed of operation plus the war-time use of new alloys and cutting tools, has created new production problems. By application of uniform temperature control, marked results have been shown on many machines.

Cutting oils which flow over the work of machine tools are used for lubrication, cooling, and for carrying away cuttings. Under present high-speed operating conditions, those cutting oils which lack sufficient cooling properties cause variations in the size, shape, and location tolerances of the work piece and of the machine itself. These variations, in a number of cases, cause shorter tool life and necessitate frequent machine adjustment to hold location and tolerances.

Now Chrysler Airtemp engineers, through their "packaged" cooling units, have developed a system of controlling the variables caused by coolants and cutting oils, making it possible to produce a uniform temperature condition. This condition, once established, can be maintained throughout the year.

PRINTING PLATES

Made of Plastics Are Light and Durable

PLASTICS printing plates have greatly increased the scope of the United States' use of pictures and the printed word in this war. Greater ease in handling the lighter weight plates has resulted in wider and speedier circulation of words and pictures overseas than would otherwise be practical. Magazines are printed from plastic plates; books are published from them; and pictures are reproduced from them.

Today, for example, the *New York Times, Chicago Tribune, Newsweek,* and *Time* use plates made of "Vinylite" plastics in printing their foreign editions overseas. The Picture Division of the Office of War Information sends to outposts all over the world 22,657 plastic plates a month for reproduction abroad. The plates are sent abroad by air mail which, if the process depended on the use of regular stereotype or electrotype metal plates, would hardly be practical because of the weight and bulk involved. Also, in some foreign locations there are no facilities for making plates from stereotype mats.

The plastics plates weigh only one-eighth as much as electrotypes of the same size. They retain detail, can be used curved or flat, are virtually unaffected by extremes of climate, are durable and machinable, and can be produced speedily without sacrifice of legible impression. Moreover, they can be produced economically in quantity.

Fidelity of reproduction of the plastics plates is the highest yet obtained by the printing industry, and the hardness and durability of the printing surface permit runs comparable with the number of impressions obtainable from the average copper electrotype. Runs of 250,000 to 350,000 are being achieved. Plastics printing plates are easily stored, are not subject to attack by moisture, and are virtually immune to weak acids, alkalies, and other organic and inorganic chemicals.

PORCELAIN ENAMEL

Sprayed Successfully By New Process

ELECTROSTATIC spraying for use in porcelain enameling has been established as a practical technique as the result of recent experimentation. The technical data accumulated at the Pemco Corporation Research Division definitely prove that electrostatic spraying is satisfactory in porcelain enameling and that when it is properly used a uniformly coated product with a minimum of overspraying can be obtained.

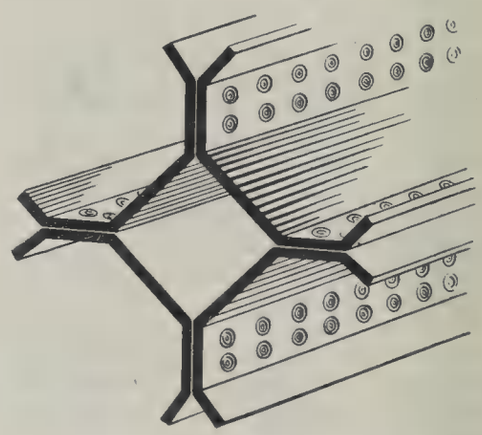
The process consists of charging the spray particles in an electric field and the attraction of these particles to the object to be coated. It is not entirely dissimilar theoretically from electroplating, with the difference that, in electro-plating, the metallic particles are suspended in a water medium. In the electrostatic process, the spray particles are suspended in air. In the use of this process the object to be coated is grounded and is surrounded by an electrical field that imparts a negative charge to the atomized particles entering the field. The particles so charged migrate in the field toward the object which bears a positive charge. The field is created by a specially designed rectifier and transformer which produces a voltage of approximately 95,000 volts with a current average not exceeding 5 milli-amperes.

WELDER

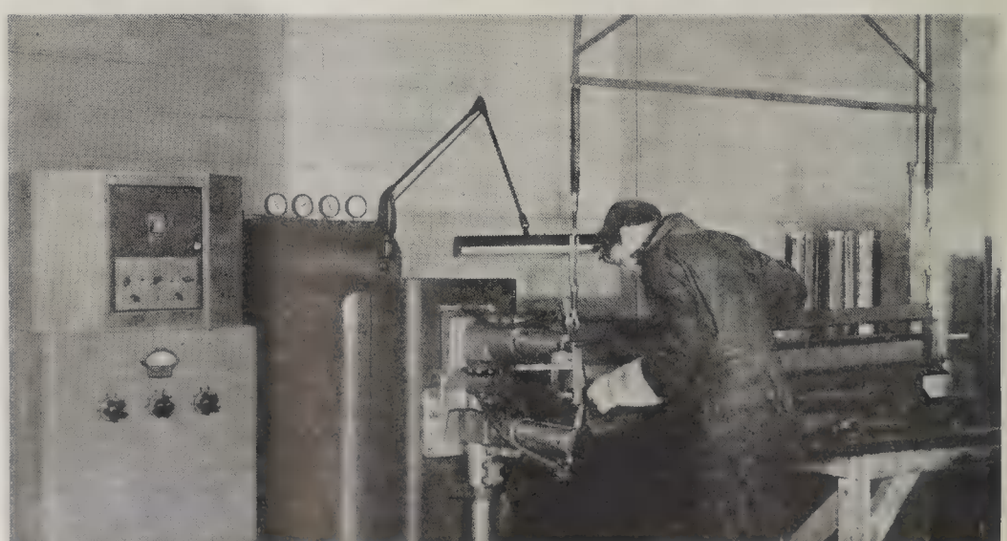
Operates on Power From Storage Batteries

DESIGNED for use in plants having only a limited amount of power available, a new storage-battery welder is coupled direct to the 220-volt shop wiring system through a battery charger which has a maximum 3-phase draw of only 26.7 kilovolt-amperes.

The welder itself is of the rocker-arm type, with batteries located in the base of the machine in place of the conventional transformer. The air-actuated contactor-controller which operates on the carbon-pile principle is also located in the base of the machine. With this type of contactor, it is the actual welding current rather than the primary current which is interrupted. The amount of current is controlled by the pressure between the two carbon disks in the contactor-



Above: Sketch of a structural section of a type being produced in large numbers on the battery-operated welding machine shown in photo below



controller. (The greater the pressure the less resistance and the greater the current.) When the pressure is removed, current stops flowing, permitting opening of the contactor by separating the carbon disks without arcing, despite the fact that welding current is around 20,000 amperes.

An unusual feature is that no compensation is required for induction losses from the first to the last weld in the assembly. Since direct current is used for welding, the amount of stock in the throat of the welder has little effect on welding current, there being no induction losses to all practical purposes.

Although in continuous operation, the 12 battery cells are kept charged by the automatic charger with its peak draw of 80 amperes, three phase. Service requirements consist mainly of adding water to the battery about once every three weeks, and occasional point dressing.

ABUNDANT SILICON

Being Put to Many Uses By Industrial Research

SIGNIFICANT industrial developments are promised by silicon, the most plentiful metallic element in the earth's crust, according to Dr. Eugene G. Rochow of the research laboratory of General Electric Company. Research in this new and unexploited field has produced some entirely unexpected and surprising results, Dr. Rochow says. Resins, varnishes, oils, and other materials have been made from silicones and their uses now include ceramic insulators to protect aircraft radios in humid atmospheres. [For other reports on silicones, see pages 66 and 114, February 1945 issue.—*Ed.*]

"Though silicon is three times as abundant as aluminum and six times as abundant as iron, the only compounds of silicon which have heretofore been important are those natural forms of silica and the silicate minerals which are used in the building arts and in ceramic technology," Dr. Rochow explains.

"Many synthetic or man-made compounds of silicon, some volatile, some soluble, some flexible and plastic, have long been known but have been confined to the laboratory as expensive curiosities. Only recently have chemists begun to explore the commercial possibilities of these synthetic organo-silicon compounds, with such surprising results that they now seem certain to become important to our daily lives.

"These organo-silicon oxides are known as silicones because they were first considered analogous to certain organic compounds called ketones. They are more properly thought of as organic-substituted sand or quartz, inheriting some of the characteristics of their inorganic and organic parentage. From these silicone structures, there have been made a number of materials, such as resins, varnishes, and oils, all heat-resistant polymers in the same way that silicon itself is polymeric and heat-resistant.

"From the troublesome 'glue-like' silicone polymers observed in the past, chemists have developed several new and different organo-silicon resins to meet many needs of the electrical industry. As is often the case, research in so new and unexploited a field has produced some entirely unexpected and surprising results. For example, it was found that the action of various organo-silicon halides on glass, paper, and cotton surfaces would render these surfaces water repellent to a high degree. Mere exposure of the surfaces to the vapor of methyl chlorosilanes suffices to impart a water-repellent film which withstands washing, dry-cleaning, and even considerable abrasion.

"Many ceramic insulators in aircraft radios are now being treated with this General Electric Dri-Film so that when moisture condenses on the insulators it will not spread and short-circuit the terminals, thereby keeping the radio operative during a rapid dive into humid atmosphere. The many uses to which such an unusual process may be put will become apparent after the war is over.

"In the course of further research on organo-silicon materials, it was found possible to make silicone oils which not only had the stability at high temperature which is characteristic of silicones, but also remained fluid at very low temperatures. In fact, the change of viscosity with temperature is so much less than that of ordinary petroleum oils that a single silicone oil often will suffice for operation of



equipment from —50 to +400 degrees, Fahrenheit. These silicone oils do not swell natural rubber nor corrode metals.

"It seems probable that the organo-silicon polymers will find use in the future not as direct competitors of the many present-day plastics, but rather in many applications where no present-day material will do, and where full use is made of the outstanding thermal durability of the siloxane network. From this viewpoint, the silicones are rightly placed as a new group of materials intermediate in properties and uses between the organic plastics on the one hand, and glass and the ceramic materials on the other."

CEMENTED CARBIDE

Makes Long-Wearing Dies For Deep-Drawing Metal

GOOD results in the production of cases for radio tubes are being obtained with deep drawing dies of cemented carbide. Here, on an operation where 100,000 pieces per die give profitable performance, some of the carbide dies have turned out as many as 750,000 pieces—400 percent more than was calculated before they were installed.

The material being drawn is tin plated sheet steel, .011 to .012 inch thick. Disks 2-9/16 inches in diameter are blanked and cupped in two operations. The first cup is 1-5/32 inch outside diameter and 1-1/8 inch high. The second draw is .795 inch in diameter and the draw angle is not blended but is cut 60 degrees. The cup is then finish drawn at size .795 by 1-11/16 inch high and with a .010 inch wall.

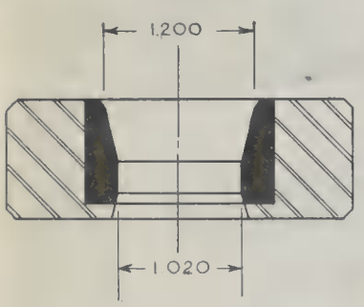


FIG 1. DRAW DIE

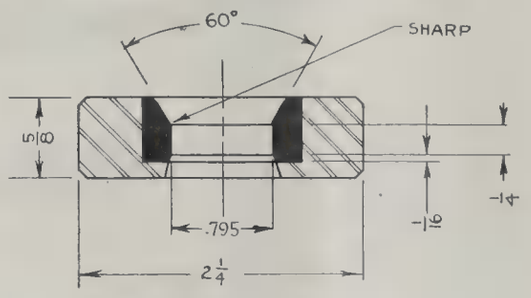


FIG 2. DRAW & PINCH TRIM DIE

Sections of the two cemented carbide dies used in the cupping operation described

Some of the Carboloy cemented carbide dies for the first draw have run as high as 750,000 pieces. One of the second-draw dies has, to date, exceeded 100,000 draws and is still turning out excellent grade work.

TWO-WAY RADIO

Speeds Up Possible Rescue at Sea

CAPABLE of operating over distances of 1000 miles or more, new lifeboat radio equipment that automatically transmits SOS and radio direction finder signals, is designed to meet the demand for more dependable communication between victims of maritime disasters and rescue forces, and is reported to be far advanced over all previous lifeboat radio equipment. Its hand-driven power generator, which replaces storage batteries, and its two-way radio-telegraph and radio-telephone facilities, are combined in a single water-proof housing.

A 300-foot antenna, carried aloft by either a kite or a balloon, is largely responsible for the greater operating distances of the new unit, a product of Radiomarine Corporation of America. A kite, a collapsed balloon in a hermetically sealed container, and a small canister of helium are standard parts of the equipment. Weather and wind conditions determine the use of either the balloon or the kite. The balloon is designed to remain aloft for a week or more.

Intended for semi-permanent installation in the lifeboat, the new apparatus may be easily transferred from one boat to another. The transmitter, which may be used for either voice or code communication, delivers five watts of power to the antenna on frequencies of 500 and 8280 kilocycles. Operating on the former frequency, distances from 50 to 200 miles can be covered; the high frequency signals will reach points 1000 miles or more distant.

In addition to conventional voice and code methods the unit is automatic in operation. The cranking of the hand-generator causes a keying device to transmit groups of SOS signals to summon aid and "long dash" signals for radio direction finder bearings. The same keying mechanism switches the transmitter frequency from 500 to 8280 kilocycles as the power is generated, thus assuring automatic transmission on both frequencies.

When two-way communication is needed, the radio receiver can be brought into action. This receiver is pre-tuned to the international distress frequency (500 kilocycles). It also can be tuned to sweep the short-wave band from 8100 to 8600 kilocycles. Once communication with ships or shore stations has been established, the two-way feature permits the drifting seamen to give information that will expedite rescue operations.

AIR CONDITIONING

Aids Precision in Bearing Manufacture

TO PROTECT high precision accuracy in vital bearing plants, air conditioning equipment with a capacity of 12,000,000 cooling units or 2000 tons of refrigeration is being used by a bearing manufacturer. Installed by York Corporation engineers in the SKF plants, the air conditioning is vital in safeguarding production of tons of bearings a day ranging in size from the diameter of a dime to six feet. A total of 550,000 cubic feet of cool, filtered air a minute is circulated through the plants by means of a chilled water system and electrostatic air cleaners.



Electrostatic air cleaning units installed in a bearing plant to remove all dirt, dust, and smoke from the air

Air conditioning in these plants is aimed at improved production and a reduction of spoiled parts.

The smallest of several thousand different bearings made are ground to a surface finish accurate to one millionth of an inch, about the same thickness as the film of moisture left by breathing on a mirror. Even a microscopic bit of moisture, such as perspiration on the hand, will attack the surface of a bearing and eat into its finish in time. Once in contact with the polished steel, it cannot be easily removed and the corrosion will continue until the bearing is repolished.

To guard against this, before air conditioning was installed, the bearings carried a coating of oil to protect them during handling. But this protection in itself created another hazard. The customary dust, grinding grit, and haze in factory air collected more easily on the heavier oiled surface and threatened to cause destructive abrasion on the bearings when they were put in use in high speed operations, occasionally as fast as 50,000 revolutions per minute. In addition infinitesimal quantities of grit and dust on the bearings made size gradings complicated.

Now the manufacturing, assembly, and inspection areas are kept at a constant temperature of approximately 80 degrees and a humidity of 45 percent. Electrostatic air cleaners in the critical assembly and inspection operations filter out nearly 100 percent

of all smoke, haze, and dust particles, delivering an atmosphere equivalent in purity to that found only at extremely high altitudes of the world.

SLIDE RULE

Tells Cutting Speeds Quickly and Easily

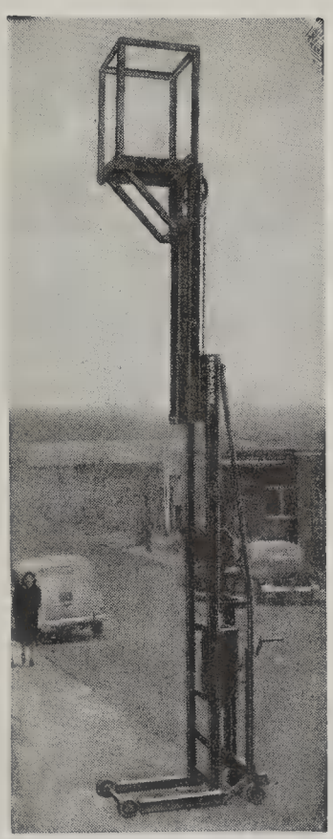
A VEST-POCKET plastics slide rule that instantly determines the correct speed for all metal cutting operations is now being manufactured. Simple operation enables machinists and supervisors to select most efficient cutting speeds for both high speed and carbide machining operations. Readings from 10 to 1000 feet per minute can be obtained. Handy size permits on-the-spot check of actual machining conditions. It is made by the Grove Calculator Company.

TELESCOPIC ELEVATOR

Has Hinged Section For Convenience

A PORTABLE elevator is being manufactured for convenient servicing of ceilings, sky-lights, overhead lighting fixtures, overhead heaters, and, in fact, all overhead repair work and cleaning at a height up to 24 feet.

The design combines the Revolvator telescopic principle with that of the hinge, as follows: Starting with the machine collapsed to a height of seven feet, the middle portion of the frame is turned up to an upright position on hinges. The upper section, with the platform at the top, is then raised by hand crank to the full height or any lesser height desired. This design permits the machine to be wheeled to the working position under low doorways or other obstructions.



Overhead repair work simplified

Although of lightweight structural steel, the machine is so designed as to be extremely rigid, with a liberal factor of safety permitting one or two men with tools to work on the raised platform without danger. The machine contains other safety features, including machine cut gears, wide spread auto-type steering, independent floor lock, self closing brake, and a device which holds the platform stationary in the event of breakage of the cable that actuates the elevator.

SURFACE GRINDER

Has Hydraulically Operated Multiple Control Valve

THE CONSTANT research necessary to provide modern machine tools for American industry has led to the development of a new innovation in hydraulic valves. This new "five-in-one" hydraulic control valve has been incorporated in the DoAll G-10 surface grinder and provides increased speed, efficiency, simplicity of operation, and greater accuracies. This new machine tool, illustrated on the following page, will grind a surface with precision to six micro-inches.

To understand the function of this new valve, the requirements of an efficient surface grinder must be considered. The G-10 DoAll has a variable table travel of 0 to 50 feet per minute with a cushioned reversing action operated by a pilot valve to give smooth, long life performance. To accomplish this, a table control valve and a table reversing valve are necessary.

The crossfeed action (indexing at the end of the table travel) is actuated by



Highly Versatile "Pencil Weld Gun" Welds Cold... Corrects Flaws and Defects ... Saves Man Hours, Materials

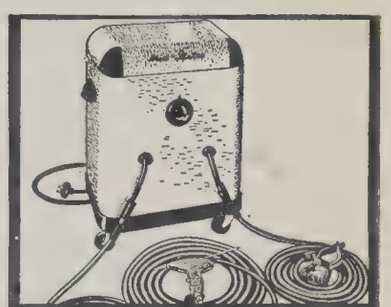
The Pencil Weld Gun, used with its Vibra-Weld Transformer, offers simplicity and versatility never before known in the industry. Equally effective in correcting flaws and defects in both ferrous and non-ferrous metals—for welding cold, without setting up stresses or crystallization.

Simple in Operation, the Pencil Weld Gun requires but a few moments' practice to achieve results formerly unobtainable with any method. Utilizing a combination of air, high amperage and low voltage, the weld never exceeds 125° to 130° F. The gun uses pure aluminum or nickel rod, which is applied directly to the defective area. When the surface has been finished and polished off, it is impossible to detect the repair. Easy to use, as gun peens and welds simultaneously. The Pencil Weld Gun and Vibra-Weld Transformer can be used wherever 220 volt single phase electricity and air outlets are available.

Unavailable, however, is Wrigley's Spearmint Gum. As the makers of Wrigley's Spearmint are unable to continue manufacture of the product up to their quality standards under present conditions, the only unqualified protection they can give to the consumer and the dealer alike is to keep the Wrigley's Spearmint wrapper empty. While they advertise this empty wrapper, none is being made and any found on the market is old production of a perishable product.



Close-up of new Pencil Weld Gun



Pencil Weld Gun with Vibra-Weld Transformer

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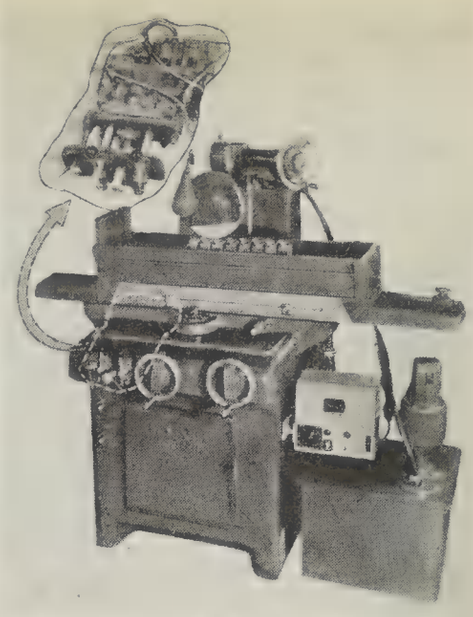
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INDUCTION HEATER

Designed for Metal Working, Has Automatic Timers

DEVELOPMENT of a new electronic induction heater for brazing, soldering, annealing, hardening, and pre-forge heating applications in the rapidly expanding induction-heating field has just been announced by the Allis-Chalmers Manufacturing Company.

With a low-loss coupling arrangement, the new electronic generator can be adapted to a wide variety of metal-working applications without the use of radio-frequency transformers. Predetermined automatic timing controls each unit operation, assuring uniform production quality. The operator pushes the start button and when the operation is completed, the unit automatically shuts off.

Other features of this electronic heater include a current limiting cir-



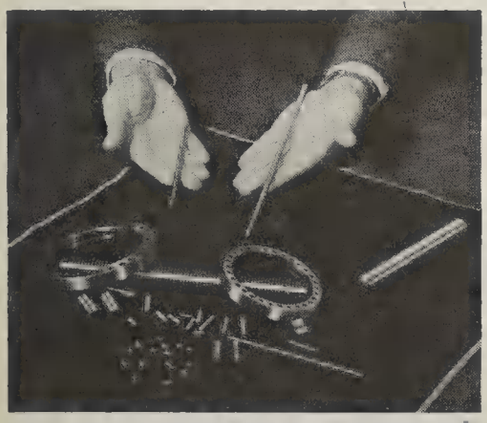
Simplified control and safety devices are features of this induction heater

cuit for protecting the oscillator filament and prolonging tube life; a three-phase rectifier on larger size units to obtain maximum power and prevent unbalance of the power line; and safety devices for full protection of operator and unit.

THREAD GRINDER

Jumps Production While Cutting Costs

BY FORMING the roots of a screw thread so that they come closer to fitting both American and British standards, a new centerless thread grinder may help to solve an international problem that has long been troubling industrialists and mechanical engineers of both nations. It is estimated that lack



Typical threaded parts produced by a new centerless thread grinding unit

of unification of screw threads has already added 100 million dollars to war costs.

In addition to cutting production and replacement costs, the new thread grinder is said to step up production output as much as four to ten times the present rate.

Key to lowered costs and faster production is the centerless principle by which the machine operates. This makes it possible to feed the parts to be threaded continuously through the machine. Up to now, this process has been intermittent. Screws and other threaded parts are turned out with extreme accuracy, according to the Landis Tool Company, makers of the machine. Nearly 100 percent of the production output meets the Class Three fit standard set up for precision work in the aircraft industry. The machine is easily adjusted and operated. One of its advantages is that it will cut hardened steel as easily as softer steel, thus eliminating the distortion and discolorations caused by heat treating the part after machining.

ENGINE IDEAS

To Increase Efficiency and Use Low-Grade Fuels

DIRECT injection of gasoline into motor-vehicle engines, with injectors to replace carburetors, and the use of a new water-alcohol device with present carburetors for truck and bus engines, are two post-war ideas suggested to improve motor vehicle efficiency.

A 50-50 alcohol-water injection mixture appears to be the most economical fluid for best results. The alcohol content used may be a blend of various alcohols for denaturing purposes and to gain the best properties of each type. It is probable that the beneficial effects of alcohol-water injection are due both to cooling and to chemical action. Best gains are realized when fuel of approximately 12 octane number lower than the engine requirement is used, according to A. T. Colwell, vice president of Thompson Products, Inc.

Gasoline injection equipment for an otherwise conventional four-stroke-cycle automotive engine is described by Harry O. Hill, of the American Bosch Corporation, as a multi-cylinder injection pump having one pumping unit for each cylinder of the engine, driven at half speed from a train of gears at the forward end of the engine. An injection tubing from each pumping unit would lead to a spray nozzle located either directly in the engine cylinder head or in the intake manifold pointing directly at the air intake valve of the engine. A master control for regulating the amount of fuel delivered by the pump so as to maintain under all conditions the proper fuel-air ratio would be mounted on the injection pump and have a tube leading to the intake manifold, or alternatively might be mounted on the intake manifold and have a mechanical linkage of some sort to the capacity control lever of the pump. In either event the master control would derive its virtue from a pressure-sensitive element responsive at all times to the intake manifold absolute pressure. It would thus utilize the engine itself as an air meter and would proportion the fuel delivery accordingly. The intake manifold would be of extra-large capacity and would contain a throttle valve for the regulation of air to the engine. There would be no carburetor or other mixing device.

Among the advantages of this equipment would be improved volumetric efficiency, Mr. Hill said. Application of gasoline-injection equipment per-

Close Limits and Fine Finish -

FOR EFFICIENT PRODUCTION

Close limits and a fine finish are essential for efficient production on many important metal working operations. Maximum output at minimum cost can be attained only when the methods and machines are such that close tolerances and the best possible finish can be maintained on piece after piece, indefinitely.

It is on this type of work—exacting toolroom jobs or production operations that call for toolroom accuracy—that the high precision and dependable performance of South Bend Lathes pay real dividends. Their smooth operation through a wide range of spindle speeds produces surprisingly fine finishes. In fact, when they are installed, subsequent finishing operations can often be eliminated.

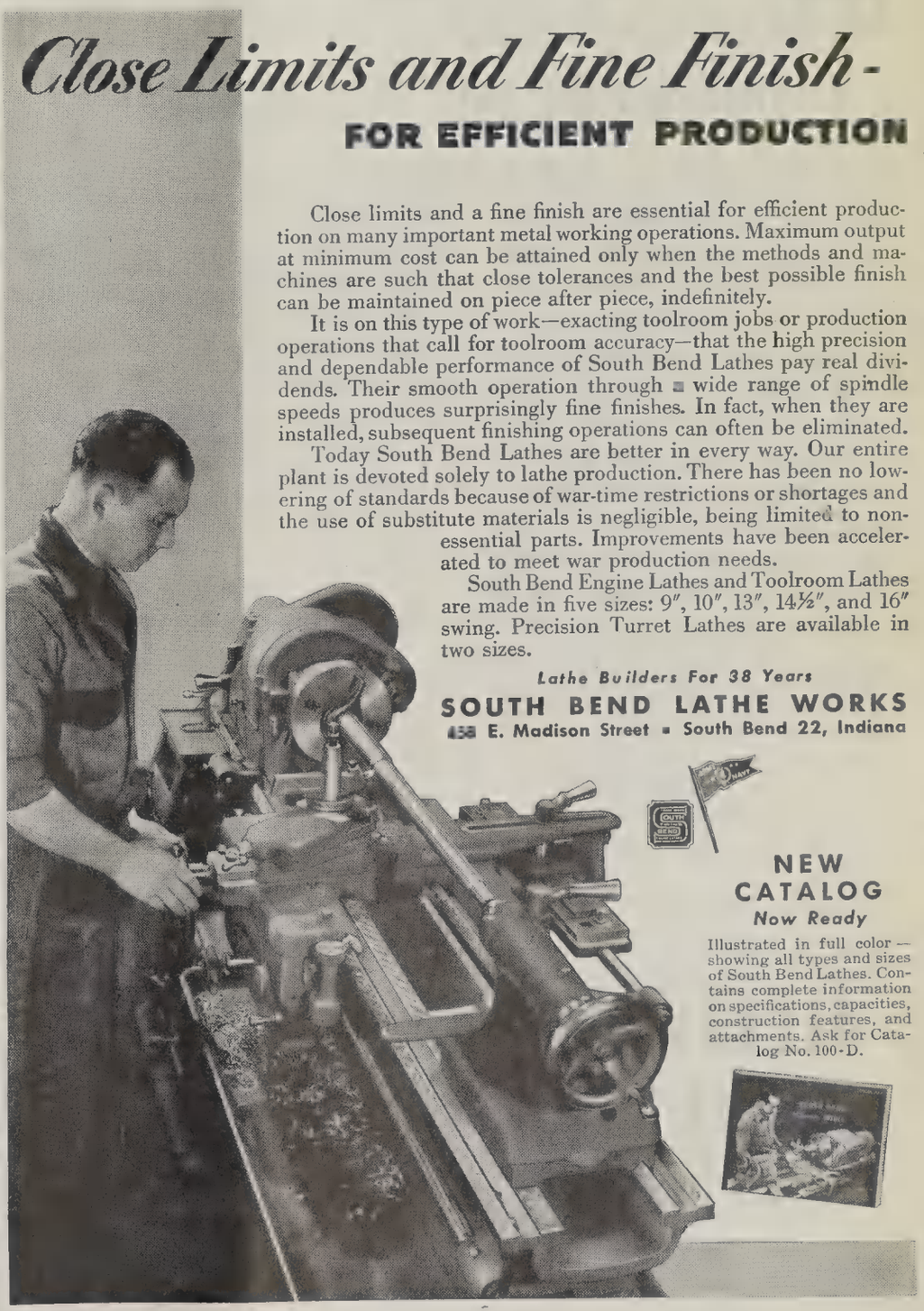
Today South Bend Lathes are better in every way. Our entire plant is devoted solely to lathe production. There has been no lowering of standards because of war-time restrictions or shortages and the use of substitute materials is negligible, being limited to non-essential parts. Improvements have been accelerated to meet war production needs.

South Bend Engine Lathes and Toolroom Lathes are made in five sizes: 9", 10", 13", 14½", and 16" swing. Precision Turret Lathes are available in two sizes.

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SOUTH BEND LATHE WORKS

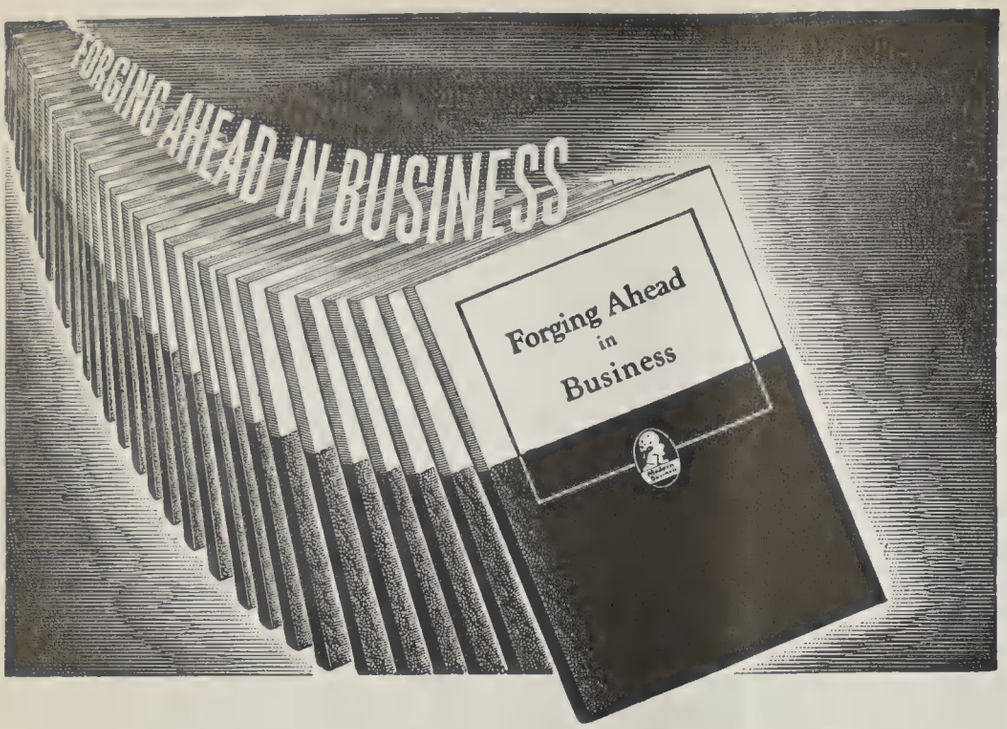
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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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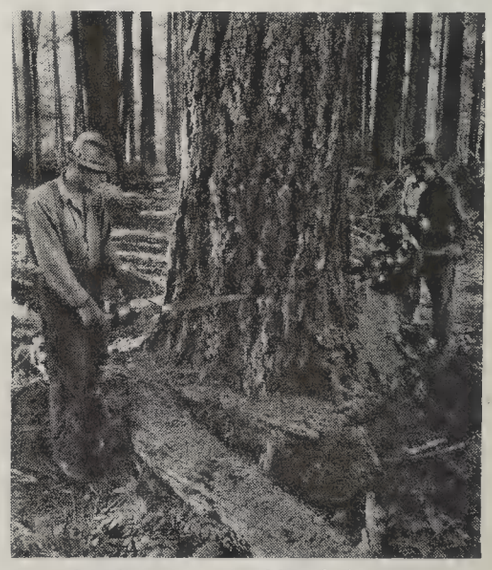
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mits the use of large intake manifolds by eliminating gasoline mixtures from the induction system and making unnecessary any reduction in manifold flow area to insure adequate mixture velocities at low engine speeds, thus avoiding the customary compromise between good idling and maximum power.

CHAIN SAW

Cuts Trees Quickly, Saving Labor and Lumber

A LIGHTWEIGHT gasoline engine timber chain saw is expected to aid in lessening the manpower problem in the timber industry and speed the output of lumber needed for war and post-war urgencies. Among the advantages of the tool, manufactured by the Mall Tool Company, is an automatic centrifugal type, stall-proof clutch. If the saw is forced too hard, or pinched, the



Gasoline powers this chain saw

engine will not stop. When the difficulty is corrected, the operator can continue to saw by simply operating the throttle.

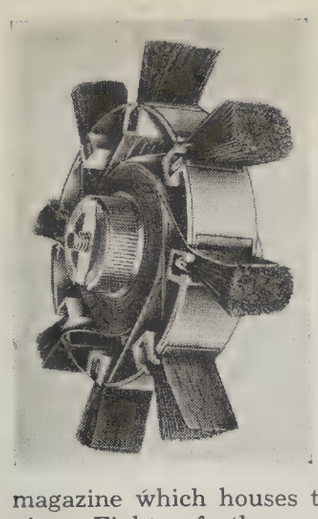
The saw is available in 24, 36, 48, 60, and 72 inch capacities. By cutting felling costs and enabling closer cutting to the stump, the saw saves timber and enables the lumberman to make greater profits. It is less fatiguing to the operators than hand sawing. Adjustment of a simple index lever permits horizontal or vertical cutting. The saw is many times faster than hand sawing and is quickly and easily serviced in the field. Another advantage is the fact that it can be quickly and easily moved over rough ground with little loss of time.

SANDER

Makes Use of Bristles to Back-Up the Abrasive

RECENTLY announced is a new, brush-backed sanding wheel which sands, deburrs, and finishes wood, metals, plastics, rubber products, and many types of special materials. The outstanding feature of this sanding device is its adaptability to jobs that were formerly done only by hand.

The device consists of a central



Eight abrasive strips extend through the housing of this sander and are pressed against the work by bristles

magazine which houses the strip abrasive. Eight of these strips extend through the housing and are held against the work by tough bristles. The bristles "cushion" the abrasive, making it possible to get in and around corners, hollow and fluted surfaces, and small openings.

Overall diameter of the Sand-O-Flex (including brushes) is approximately eight inches. Weight fully loaded is about 2¾ pounds. Normal loading contains 20 feet of abrasive and reloading is done simply by unscrewing a serrated nut and removing the cover. A wide range of abrasives of various grits and grades are supplied for use with the sander. These cartridges, plus the quick-changing feature, permit the same tool to be used in all operations from rough stage to polished surface.

DUST COLLECTOR

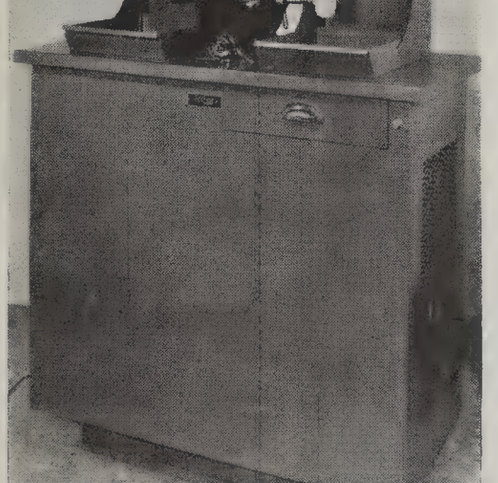
Made Specially For Laboratories

A SELF-CONTAINED combination dust collector and bench designed for collecting both wet and dry dust, dirt, lint, pumice, and so on, in dental and similar laboratory work is now available. Requiring no installation other than merely locating and plugging in the cord to the nearest electric light outlet, Lab-Bench dust collector not only eliminates time usually needed for cutting and fitting for installation, but has an unusual amount of storage space for the collected dust and dirt.

The design permits all the material to be separated out of the air stream before the latter enters the fan. Hence, any type of material can be handled without wear to the fan blades.

A self-shaking feature of the bag type filter also eliminates maintenance, and renewal of the filter element does not have to be made except at most infrequent intervals.

Recovery of precious metals such as gold and silver is easily made when the collected dust and dirt is removed from the bottom of the collector. Precious metals that have become lodged on its surface or imbedded in the filter can be recovered simply by burning the filter which is inexpensive.



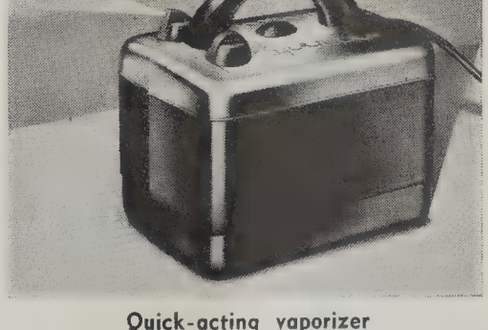
Filters and fan of this self-contained dust collector are in base

VAPORIZER

Produces Steam Quickly, Shuts Off When Dry

HOLDING a full half gallon of water, a new Spartan vaporizer discharges a "dry steam" type of vapor less than one minute after connection to an electrical outlet—even though extremely cold water has been used.

Entirely automatic in action, the unit does not require the addition of any extra ingredient, such as salt, to enhance fast starting, and it shuts off as soon as the water chamber is empty. A special compartment is provided for the medicant. The main body, handle, and several parts are molded of a special Durez plastics which resists heat, water, and chemicals, is easy to clean and to keep clean, and is self-insulating. The cover is of smoothly finished aluminum. The complete unit is only 5 inches high, 5½ inches wide, and 7¾ inches long, and weighs approximately two pounds when empty. While the vaporizer is designed primarily for relief of bronchial ailments, its capacity suggests its use as a humidifier for offices and sleeping rooms where humidity is too low.



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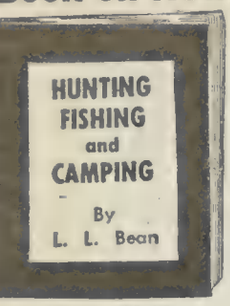


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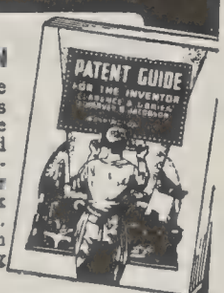
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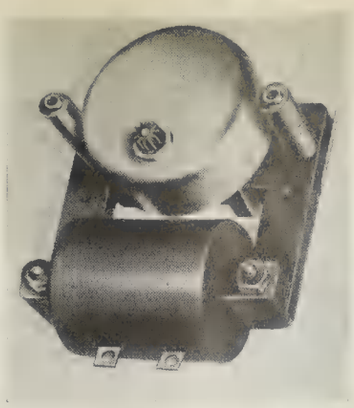
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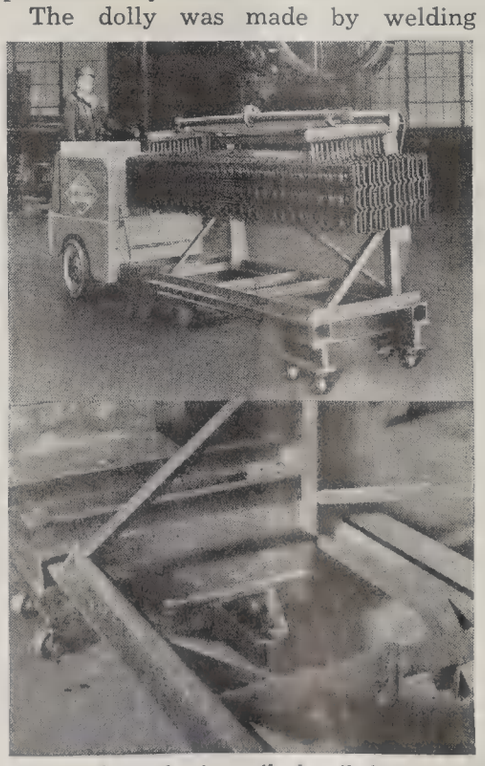
burner and coal stoker controls, and other apparatus in which minimum space and slow speeds are necessary. This new motor, a product of the Warren Telechron Company, has an input rating of two watts and can be furnished in other speeds up to and including six revolutions per hour. A special oil gland has been built into the terminal shaft bearing, thereby extending its life greatly under industrial and domestic operating conditions. The terminal shaft is concentric with the outer case of the motor.

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The dolly was made by welding



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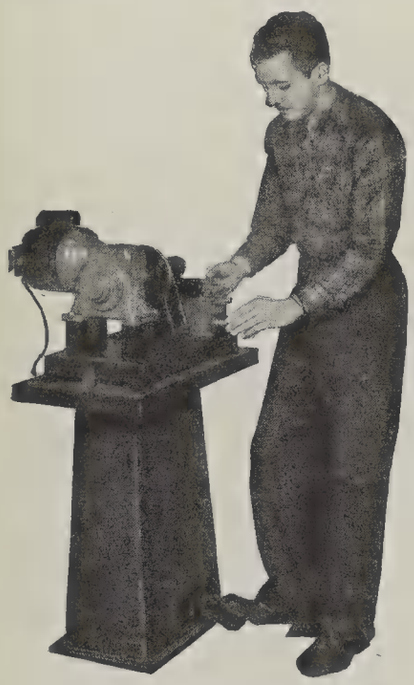
flame-cut parts of standard flat rolled shapes. A steel fitting bolted to the forward end of an Elwell-Parker power truck platform provides for a pin connection between the base frame and the truck. The truck lifts only one end of the dolly and can either push or pull the load through narrow aisles and around corners with ease and safety.

This arrangement for handling loads of long pieces has the advantage that the truck can be made quickly available for handling other types of loads on skids in the same plant. It can easily be modified to accommodate other types of material in long lengths such as tubes, bars, small trusses, and the like.

INDENTING MACHINE

Rapidly Produces Straight-Line Impressions

AN INDENTING machine that marks straight-line impressions on metal parts at a high rate of production has been given the trade name Gottscho Indenta #10. The moving parts consist mainly of a sector of a round steel die,



High-speed metal marker

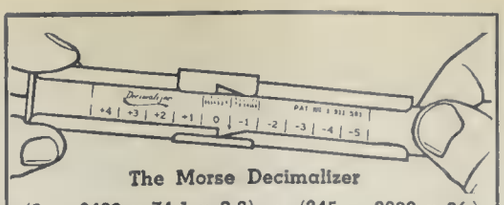
which makes a half turn and stamps an imprint into the metal part. The die then returns to its starting position, the marked part is removed, and a new one put in its place.

The actual marking occurs in a fraction of a second, so that production is dependent on handling. If parts may be smoothly conveyed to and from the machine, production may be higher than 1200 per hour, according to the manufacturer. A friction clutch prevents jamming.

FANS

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TWO NEW axial flow fan units, one 60 inches in size and the other two inches, have been announced by Dynamic Air Engineering, Inc. The 60-inch low-pressure propeller, driven with a 10-



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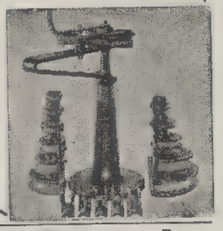
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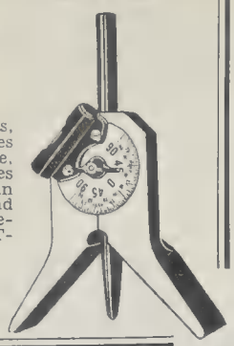
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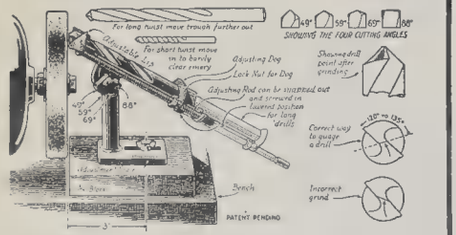
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Current Bulletin Briefs

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ARRIVED O. K. is a well illustrated booklet which shows, step-by-step, the methods of sealing fiberboard and V-board shipping containers and waterproof case liners for export shipments. The adhesives used are made to meet government specifications to withstand rough treatment, extremes in temperature, and high humidity. *Minnesota Mining and Manufacturing Company, Saint Paul 6, Minnesota.—Gratis.*

NEVILLE RESINS AND PLASTICIZERS is an 82-page booklet presenting new information on applications, detailed specifications, properties, and other characteristics of a number of these products. A preview of new resins, solvents, and pure chemicals, some available in sample form only, are described. *The Neville Company, Neville Island, Pittsburgh 25, Pennsylvania—Gratis.*

THE CONSULTING CHEMIST AND YOUR BUSINESS is a brochure outlining the type of business enterprise which finds use for the services of consulting chemists and describing some of the branches of service offered, including research in rubber and plastics, organic synthesis, physical testing, chemical engineering, and calibration service. *Foster D. Snell, Inc., 305 Washington Street, Brooklyn 1, New York.—Gratis.*

MANUAL ON FLEXIBLE METAL HOSE USE is an illustrated catalog dealing with a complete line of hose construction, flange and coupling types, vibration absorbers, laundry and platen press units, and other specialties. *Packless Metal Products Corporation, New Rochelle, New York.—Gratis.*

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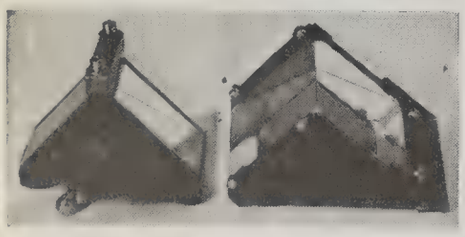
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CONCRETE, offered as a material for telescope making by Russell W. Porter in "A.T.M." (chapter on mounting design, Figure 7, "Porter's Folly"), has not yet met with general favor, perhaps because there is a feeling that concrete is crude. Frederick H. Minard, 834 Thayer Ave., Los Angeles, California, with Edward A. Carson of Los Angeles, has now constructed "Porter's Folly" of concrete in 10″ *f*/10 size, (Figure 1). The conical polar axis is made of 16-gage steel attached to a 27″ flywheel and poured full of concrete. That part alone, with the concrete-filled, 16-gage steel fork, weighs 1250 pounds.

Asked to particularize, Minard (Figure 2) writes:

"After carefully studying the two volumes on amateur telescope making we decided that 'Porter's Folly' was not at all, as he nicknamed it, a folly but a feasible idea. So we set to work and it took us the better part of a year to complete the entire installation. Edward A. Carson was associated with me; in fact, the telescope was constructed and installed at his estate in Bel-Air, this city. The results proved the soundness of Mr. Porter's idea and it is a most satisfactory instrument in every way.

"Upon viewing the instrument it would never be suspected that the main elements were constructed of concrete. The basal block, containing three adjusting screws on the bottom, is a plain concrete block, poured in the usual way in a wooden form. The latter was removed and it remains a concrete block, but it is all below the observatory floor level and is not visible. It is covered by removable floor sections.



Figure 1: Porter's Folly

"Now comes the disguise of the visible polar axis—the right ascension circle is a flywheel, 27″ in diameter, into the hub of which is fitted a long 2″ shaft, trued in a big lathe. On the lower part of the shaft is welded a 16-gage steel disk about 12″ in diameter. Then a 16-gage truncated steel cone was rolled and welded on to this assembly, the large end fitting inside the rim of the flywheel and the smaller end on the 12″ disk.

"Into this assembly were placed the long rods which hold the declination bearings and around these rods were placed shaped 16-gage steel forms and these forms make the outline of the yoke, which shows in the photograph.

"Having this concrete-metal structure all set and trued up, the entire layout was stood up with the small disk end down and the entire form was filled with concrete.

"The only concrete surface that shows is in the center of the flywheel around the hub top and, as this is painted black, no one would suspect there is any concrete in the construction. Not even a trace of a crack has ever appeared on this small exposure. In fact, the entire polar axis looks as though it were turned out of steel.

"One can kick the polar axis to the extent of almost breaking a toe and there is no vibration of the telescope tube.

"The telescope driving mechanism is located at the lower end of the polar axis, entirely below the floor level, in a concrete vault. Consequently, the observer is always in a comfortable observing position and even at the meridian has only to mount two steps above the floor level.

"The weights are: Tube (16-gage rolled steel), 55 pounds; mirror and cell, 29 pounds; lead counterweight ring, just above cell, 350 pounds; tube bearing ring with trunnions (one-piece aluminum), 26 pounds; upper end ring with flange and revolving head (aluminum), 26 pounds; revolving cone, steel-jacketed concrete, 1250 pounds; concrete three-point bearing block, 1500 pounds. Total, 3226 pounds.

"It is a very stable telescope and free from vibration, yet the part showing above the floor does not look massive.

"The observatory is fitted with flanged wheels on the bottom of the dome and the entire dome revolves on a 20-pound circular rail on a concrete foundation. The observer can easily push it by hand. The floor of the observatory is of concrete on which is laid heavy linoleum."

Porter, who went to see this telescope and its handsome and practical dome, reports: "'Porter's Folly' is at last vindicated. It's a mighty good job and it works. Steady as the Rock of Gibraltar. A concrete telescope mounting!"

True, this telescope is largely concrete but it still is not quite a concrete mounting unashamed. Yet, though so much of the concrete work we see here and there looks ratty, it remains nevertheless possible to do concrete work that looks finished and refined. To accomplish this let the worker forget most of the working technique he has picked up from sundry laborers, foremen, and contractors. Let him then obtain scientific instructions from a sound source (for example, the Portland Cement Association, 347 Madison Ave., New York) and carefully study those instructions and the principles behind them. And then let him follow them to an extent that seems fussy, taking special pains to obtain low water content, to ram the placed "mix" well and cure it really adequately.



Figure 2: Minard and dome

Such work should be free from the cracks and spalls and other flaws so commonly seen in concrete.

SOME seeds gestate a long time before sprouting. The short chapter on "Dealing with Spider Diffraction," in "A.T.M.A.," reached notice in 1941 in the July-August number of *The Journal of the Royal Astronomical Society of Canada* (198 College St., Toronto, Ont.) in an article by C. H. Werenskiold, from which the following is quoted:

"This method consists in placing, in the open end of the telescope, a diaphragm having four elliptical openings, in such a manner as to cover or hide the four straight arms of the spider and in effect provide them with a curved outline. A modified procedure is also described in which the spider arms are covered with small plates or screens of curved outline. The spikes

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or cross-bars in the star images were eliminated in both cases.

"The use of diaphragms or screens naturally causes a certain loss of light, and it has occurred to the writer that this loss can be reduced to a minimum by curving the spider arms themselves, which would render the use of diaphragms or screens unnecessary.

"Several methods for accomplishing this are possible, of course, such as suggested in Figure 3, at 1, 2, and 3, and where *E* indicates the position of the eyepiece and *P* that of the assembly supporting the prism or diagonal.

"Up to recently the writer has employed the 'straight' spider construction of 4, made from brass strip approximately 1" x 1/16", in an 8½" reflector, and no substantial mechanical weakness or vibration due to the omission of the fourth spider arms has been noted. The star images with this spider naturally exhibited the usual spikes. In considering the various possible curved spider designs, the one shown in 1 appeared most attractive from a mechanical standpoint, since its arch-like design offered strength and stability, together with a reduction of the number of spider arms to two. A curved spider of this type, made from brass strip approximately 1" x 3/32", was substituted for the straight spider formerly employed and has been found both mechanically satisfactory and effective in eliminating the spikes from the star images.

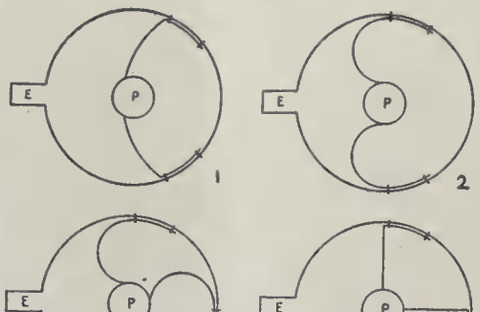


Figure 3: Four spider types

"Furthermore, the definition obtained in the observation of planets, such as Jupiter and Saturn, appeared to be considerably improved. This is readily understood when we consider that the bright disk of a planet as seen in a telescope constitutes a pattern composed of smaller light elements. Each of these, depending on its individual brightness, gives rise to more or less luminous cross-lines or spikes when a straight spider is employed, with the total result that the image of the planet is accompanied by a hazy, more or less noticeable, cross-band of light, approximately as wide as the diameter of the planet and oriented in the manner of the usual star spikes. It seems obvious that the definition would suffer under such circumstances, the fine detail originally rendered by the mirror being again partly obliterated by the superimposed cross-band of light. Since no such cross-band is formed when a curved spider is used, the definition is improved accordingly.

"As to the practical construction of the spider 1, it was found desirable to prepare an exact drawing beforehand and to calculate geometrically the overall length of the spider to determine the exact position of the bends adjoining the telescope tube. In order to obtain satisfactory results, one must make certain that each spider arm is curved continuously without any straight sections. As the work progresses, the shape of the spider should therefore be compared carefully with the drawing. A liberal additional length of strip was allowed for fastening the spider to the telescope tube with short bolts. The holes for the bolts were elongated lengthwise of the strip, and the corresponding holes in the tube were elongated at right angles to this; that is, lengthwise of the tube, to the extent required for adjusting the spider to its correct position.

"The more strongly curved forms shown in 2 and 3 may have certain advantages in construction, such as lessened danger of straight sections, but whether these modifications are otherwise practical has not been investigated.

The same subject is discussed in mimeographed Mailing 20, of the "Astronomical Information Sheets" (a service for placing information on new comets, novae, occultations, and so on into amateur astronomers' hands quickly: 20 mailings, a dollar, G. B. Blair, Dept. of Physics, University of Nevada, Reno, Nevada, Editor) by Clarence W. Parham Sr., 2354 Woolsey St., Berkley, California, who has had excellent results with the streamlined spider in his 6" reflector and will be glad to answer any questions proposed by interested amateurs. He made his spider of a single strip of 3/32" x 1¼" brass bent as in 2. Where sharp bends were needed at the ends, the strip was grooved with a hacksaw, then bent, and the groove filled with solder.

In Mailing 44 of the same "Information Sheets," Carl E. Wells, 419 Oak St., Roseville, California, states: "Mr. Franklin B. Wright, 155 Bret Harte Road, Berkeley, drew my attention to the fact that this spider must be curved in multiples of half circles—that is, one half circle, one circle, one and one half circle, and so on. Also, your prism holder should present a full circle to the light rays. A square prism holder will destroy the effect you are trying to get with the streamlined spider."

To those who are designing Maksutov telescopes, the following, from the author of the articles in the October and December numbers, should be of interest. "I wish you would kick me good and hard, as there is an error in the December article, page 285, first column, at bottom. The figure .122 should instead be half that, or .061," and the other figures mentioned in relation to it are wrong to the same extent. I picked up the figure for a diameter instead of an aperture radius. My apologies to all and sundry."

The Maks are still delayed because those who had nearly finished them suddenly took war production contracts.

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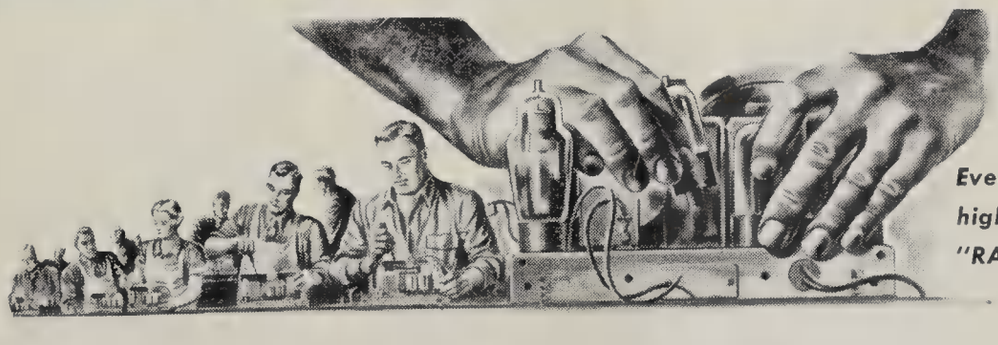
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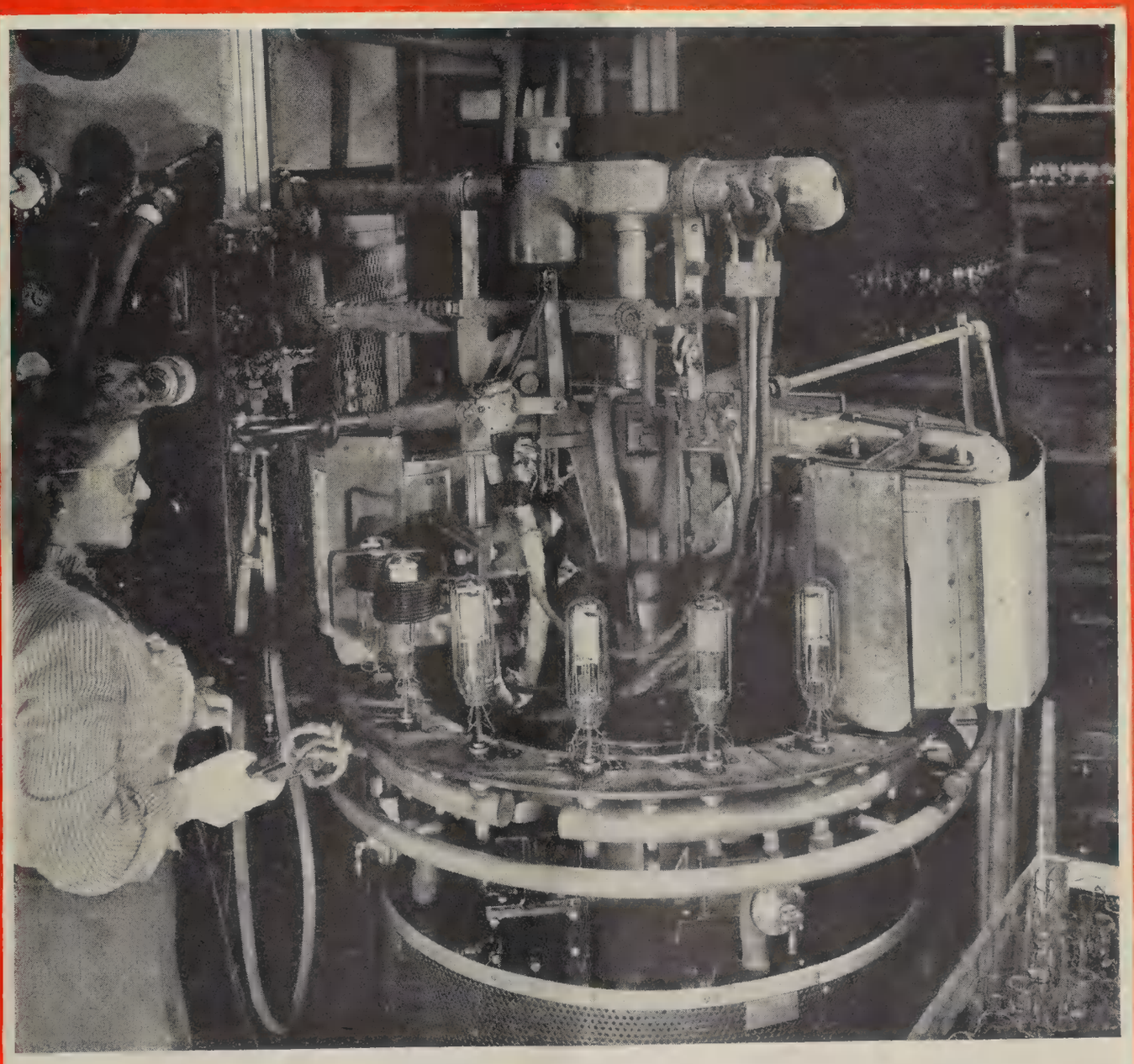
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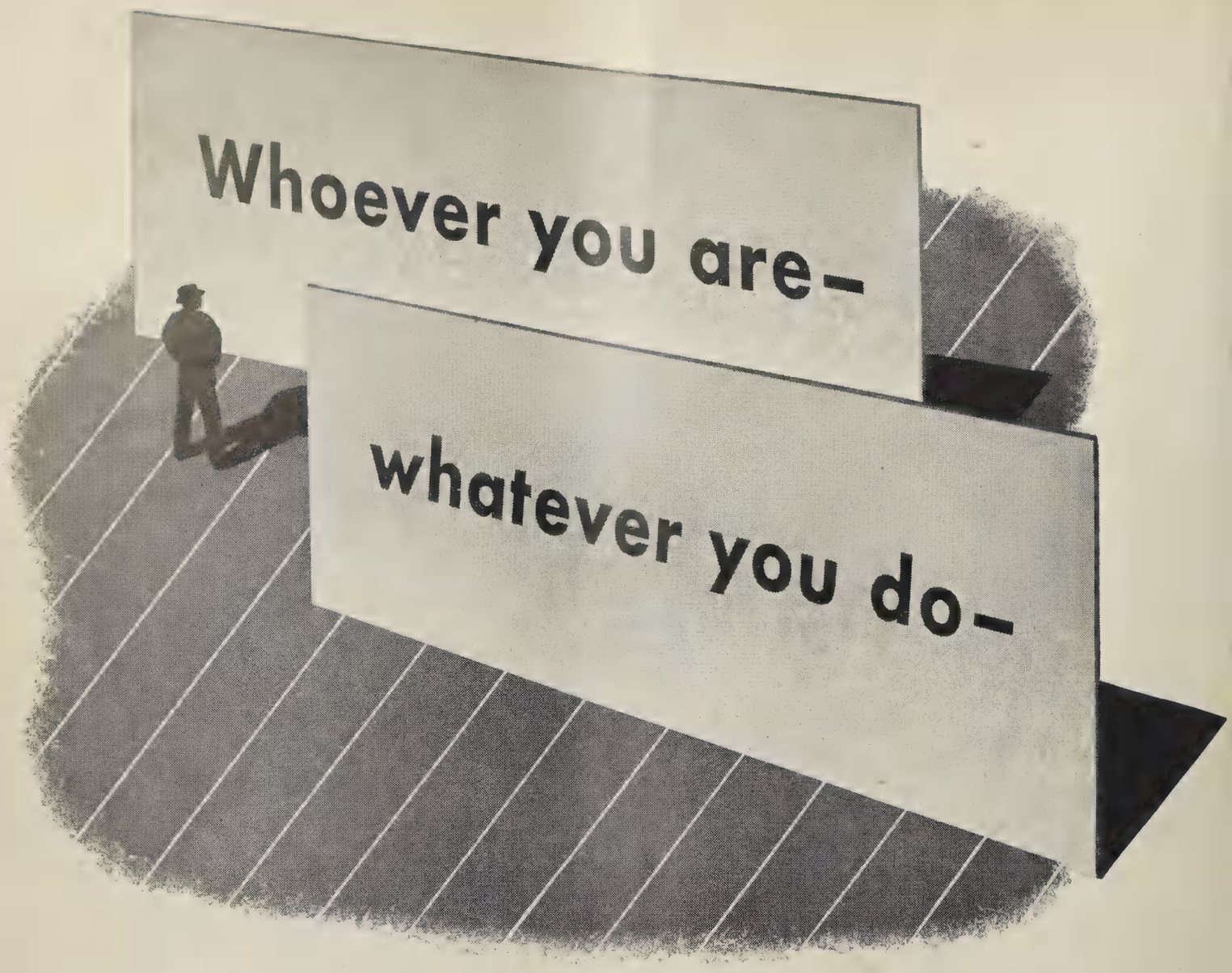
REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Electronic Eyes, Ears, Brains . . . See page 1

The Story of ELECTRICITY AND ELECTRONICS

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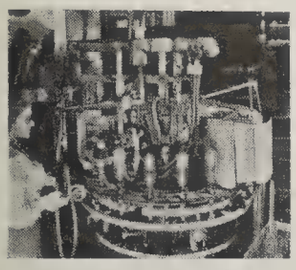
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Our Cover: In the days of World War I, removing the gas from a vacuum tube required long and painstaking effort on the part of artisans skilled in the craft of glass blowing. Today semi-automatic mechanisms—the one illustrated was evolved several years ago—perform the same job in a twinkling, exhausting hundreds of uniformly processed tubes each working day. Vacuum tubes, in a multitude of forms, serve as eyes and ears and even brains in military and industrial applications. Photo courtesy Western Electric Company.

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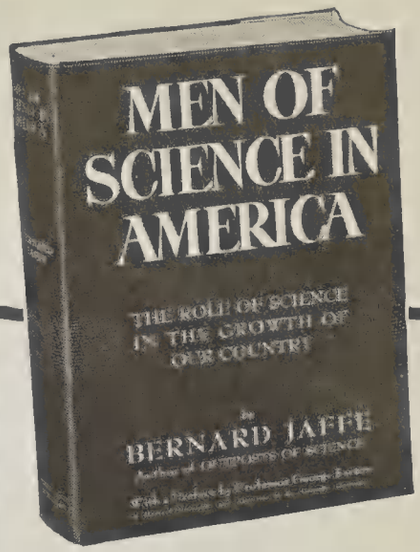
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—New York Herald Tribune

Professor George Sarton of Harvard has written the foreword. The book contains 600 pages, 28 plates, and 25 text diagrams. Third printing.

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SIMON AND SCHUSTER, Publishers

Previews of the Industrial Horizon

By A. P. Peck

DEFROSTING BY ELECTRONICS

ELECTRONS first came to the aid of the food industry by powering compressors for quick-freezing; now they are serving a new purpose on the other end of the food line—defrosting those same foods in a matter of minutes instead of the hours formerly required. To the housewife the matter of defrosting frozen foods may seem of little moment. To bakers and other users of large quantities of frozen fruits, berries, eggs, and so on, however, the time element becomes important. Not only that, but it is reported that large blocks of frozen foods decrease in taste- and food-value when permitted to thaw slowly at room temperature.

The way in which electronics is solving this problem, according to authorities of the Great Atlantic and Pacific Tea Company, is by means of the well-known and widely used industrial process of dielectric heating. Simply by placing the frozen materials between the plates of a dielectric heating unit and turning on the high-frequency current, defrosting is accomplished quickly, economically, and effectively.

WHICH MODULATION?

STANDARD broadcasting methods, employing so-called amplitude modulation, permit operation of only about 900 stations in the United States. A greater number of wavelengths than this would create confusion comparable with that of the early twenties. On the other hand, frequency modulation, tried and proved during the past five years, would permit operation of some 2000 to 5000 stations in that part of the spectrum now assigned to it. The seeming paradox is due to the property of frequency-modulated waves of reaching only to the optical horizon—usually under 100 miles.

In this limited range of FM is to be found one of its greatest advantages for the furtherance of the things that only radio communication can give to the public. Local stations, providing the same sort of local service as the small-town newspaper and having vast influence in the community, can make use of FM in a way that would be impossible with amplitude modulation. The FM transmissions are free of interference; thus with this system it becomes possible to have a local radio station in every community in the United States with a population of over 2500.

Of course, the great radio chains, using AM, cover vastly more territory than is possible with FM. Their income is dependent upon this great coverage. At the same time, however, they cannot give time to subjects of primary importance to local communities except during the daylight hours when audiences are naturally limited. If the chains would take full advantage of the golden opportunity before them, they will tie in with local FM stations. In this way they would not only meet competition but would broaden their own systems and give an even better public service than the excellent one which they are providing today.

MOTION STUDY

TIME and motion studies are all too often linked with slave-driving proclivities on the part of the employer. As a matter of fact, they should be considered in the light of over-all benefactions—to employer and employee as well. When a worker's methods of operation are changed as the result of time and motion studies, he not only does more work and produces more, but at the same time he accomplishes his labors with greater comfort and less fatigue.

Now comes a new angle of motion study. Initially it is being applied to determine the size and design requirements of home units—kitchen, bathroom, dressing room, and the like. These studies are an attempt to fit the home to the individual rather than the individual to the home. Their purpose is to make the greatest use of space for a given requirement and thus reduce to a minimum the losses that go hand-in-hand with room design based on tradition rather than on science.

From this new form of motion study, carried out photographically and then transferred to three-dimensional models, industry can learn a lot. Empirical placing of machines and equipment can give way to a scientific placement method that will allow more workers to occupy a given space comfortably or, on the other hand, a given number of workers to use less space with increased efficiency. With reconversion already well under-way, consideration of truly scientific motion studies can mean the important difference between profit and loss.

ELECTRONIC DUSTING

LOOMING on the horizons as something that industry has ready for the housewife is what has been called "automatic dusting." Actually, it is a part of an air-conditioning system that, by electronic means, precipitates all dust particles in the air introduced into the home and hence reduces the dusting chore to a minimum. It is said that the "automatic duster," by removing dust from the air before it has a chance to settle on furniture, makes it unnecessary to dust the equipped home more than once a month.

This equipment is no dreamer's vision. For many years it has been salvaging valuable dusts in industry, protecting delicate parts and materials from foreign particles, and abating the smoke nuisance. Now it is ready to go to work in the home, bringing even more leisure to the housewife.

PRE-PACKAGING

PACKAGING improvements have reached a new high as a result of the war, and automatic machinery has been developed that will give faster production, save floor space, and economize on wrapping material. Side-by-side with these advances is coming a realization that many bulk products to be offered for sale to the public can be more readily sold if they are attractively wrapped ("pre-packaged" is the word being used) at the point of production rather than done up in paper after sale. Trials so far reported indicate substantial sales increases coupled with faster sales service.

FOR FUTURE REFERENCE

TELEVISION, just about to turn the oft-mentioned corner, is attracting the attention of Hollywood, with movie producers reported as lining up all television possibilities for exploitation. . . Radar's most important implications are that it is now possible to produce, with high power, those interesting radiations lying between light and radio as radio was known post-war. . . Electronic vulcanization of rubber, producing heat uniformally throughout, promises far superior rubber articles than were ever possible before. . . Correct lubrication of machinery, even by unskilled labor, will be possible by a new color system recently developed. . . A new vitamin that reportedly relieves certain types of stiffness in joints and muscles is made from milk and molasses. . . The air transport industry states that it will need four times as many planes post-war as it now uses. . . "Highly favorable" results in rejuvenating nearly exhausted oil wells have been obtained by pressure-pumping water into the oil-bearing strata, thus literally squeezing out the remaining crude, whereupon it can be pumped to the surface.





1945—London to New York—7 minutes



1926—New York to London—1 hr. 35 mins.

Notice the great improvement in clarity, as well as in speed—both results of RCA research. Radiophoto prints are no longer blurred by a "pattern." Today, they're about as clear and sharp as the original photograph snapped thousands of miles away.

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RCA radiophoto transmits pictures halfway around the world and prints them—*in a matter of minutes!*

And thanks to RCA research, pictures now come through the receiver (shown above) just about as sharp and clear as the originals themselves.

Through RCA radiophoto, today's "news shot" in Honolulu or Cairo can make tomorrow morning's front page. Or—blueprints for a disabled power generator can be flashed to London—saving hundreds of vital war production hours.

Advertisements, fingerprints, documents and letters are radiophotoed by RCA Communications—as many as 2000 a month! Even musical scores—such as the new "Trio" by the great composer Shostakovich—are sent by faster, error-proof radiophoto.

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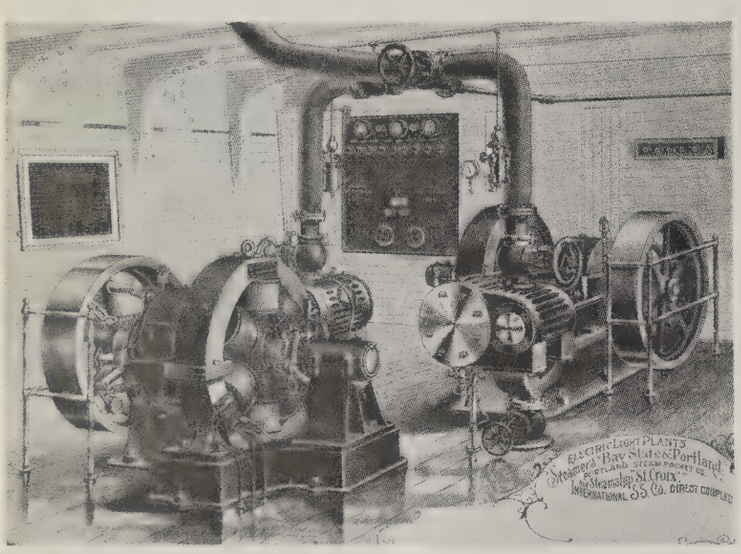
SCIENTIFIC AMERICAN

(Condensed from Issues of July, 1895)

ELECTRICAL POWER — "The electrical industry is about 17 years old and employs over $1,000,000,000 of invested capital. The greater part of this immense investment has been made since 1888, when the electric motor was proved to be a success."

STONE — "Stone, like lumber, requires seasoning. Stone is often spoken of as the synonym of solidity—'as solid as a rock,' we say, but, as a matter of fact, stone is very far from being solid. A cubic foot of the most compact granite, for instance, weighs about 164 pounds, while a cubic foot of iron weighs 464 pounds. This plainly shows that in between the atoms which compose the mass of the most enduring stone there exists much space for air, moisture, and so on. . . . The seasoning of stone prior to use for building purposes has been well understood by the architects of all ages, but in the modern rush of nineteenth century building too little attention has been paid to it. Now it enters into the calculations of every good architect."

SHIP LIGHTING — "The accompanying illustration represents the electric light plant on the new steamer Bay State, of the Boston and Portland Line. The dynamos are multipolar slow-speed machines of 400 lights capacity each, but



either machine will carry the entire load, amounting to 540 lights. . . The dynamos were designed by Mr. W. H. Chapman, electrician for the company. . . The fixtures are of the latest design, with opalescent globes and shades. The dining saloon is fitted with ground glass globes, which gives this part of the boat a very pleasing effect."

STEAM POWER — "Some time ago the Ohio Steel Company, of Youngstown, O., not being able to generate sufficient steam with the boilers already constructed, and not wishing to wait for the completion of those in course of erection, obtained six locomotives from the N. Y., L. E. & W. RR. Co.'s round house, and, placing them side by side at the rear of the engine house, connected them up to supply steam to the extent of 600 horse power."

LIGHT BUOYS — "Incandescent electric lamps on spar buoys have been experimentally used in New York Bay for several years, but an installation has now been completed which marks a considerable advance in maritime engineering and renders the entrance to New York Harbor possible for the largest vessels at any hour of the night. Gedney's Channel . . . is now lighted by 10 incandescent lights of 100 candle power each. The lamps are mounted on 50 foot cedar buoys which are shackled to 5,000 pound mushroom anchors. The cable is constructed of a copper conductor, insulated with gutta-percha, then bedded with jute and sheathed with an armor of hard drawn copper wires. This cable carries successfully a pressure of 1,000 volts alternating current under water for the distance of 6½ miles."

PAPER — "Adansonia bark is chiefly used for the preparation of strong wrapping papers, cartridges, and emery paper. In point of strength the fibers obtained from it are only surpassed by those from the mulberry bush. Papers made with an addition of adansonia fiber not only possess greater tensile strength, but offer greater resistance to tearing."

AVIATION — "It is proposed to include an international exhibition of aeronautical apparatus among the interesting features of the Paris Exposition of 1900. The sub-committee on aerostation in charge of the matter are making preparations for the admission of balloons of all kinds, flying machines and soaring apparatus of every description."

TROLLEY LINES — "Electric lines now connecting with the business center of Chicago, either completed or under way, give a grand total of 500 miles. The benefit of such transportation facilities to a city can hardly be overestimated for the speed of travel will average nearly eight miles per hour or twice that of horse car lines. . . . The operation of the trolley lines is almost perfect, as the cars run smoothly and without delay, there being very few accidents to persons or machinery."

AUTOMOBILES — "Since the early days of the present century a practical road carriage which should carry its own means of propulsion has engrossed the attention of many inventors. Today we are treated to a spectacle of an automobile carriage with four passengers which can travel 750 miles at the rate of nearly 16 miles an hour."

POWER TRANSMISSION — "The first practical demonstration of the system of transmission to be employed by the Cataract Construction Company in carrying the electric power to its customers took place June 29. Two thousand horse power was conveyed from the power house to the works of the Pittsburgh Reduction Company, a distance of three-quarters of a mile."

WOOL CLEARING — "The employment of naphtha as a cleansing substance in the scouring of wool is a new method favorably commented upon by the scientific papers. By the use of a pump the naphtha is forced through and through the wool, extracting all the natural oil, it being also claimed that the naphtha does not injure the fiber of the wool, as does alkali cleansing, but leaves the fleece in an actually better condition than when cleansed by any other process."

WIRE ROPE — "While conducting a series of tests with a 100 ton testing machine at the Yorkshire College in England, which included the testing of a steel wire rope, Prof. Goodman stated that such ropes were not a modern invention, and that he had recently seen a bronze wire rope one half inch in diameter and from 20 to 30 feet long which had been found buried in the ruins of Pompeii and which must have been at least 1,900 years old."

ARC LIGHTS — "In an arc light produced by alternating currents, both carbons are consumed at the same rate and both remain pointed. Carbons burn faster with the alternating current than with the direct."

HOT COOLING — "A fire started in the steamship Massachusetts at the foot of West Twenty-ninth Street, New York City. The outbreak was in the meat storage room in the rear hold, and was caused by the friction of two large electric fans which are used to keep the meat cool."

TELEPHONE SIGNAL — "A small electric lamp is being used instead of a bell in some telephone exchanges in England. The call for connection lights the lamp."

DUPLICATING A GERMAN VACUUM TUBE IN 3 DAYS

Just behind the battlefront, a telephone system lay dead. The retreating enemy, hoping to return, had not blown it up, but had taken with them its vacuum tubes. To put it back to work, the General ordered 1000 new tubes — spot delivery.

A sample tube was flown back to the United States and brought to Bell Telephone Laboratories. It was of German design, different from any American tube in both dimensions and characteristics. Could it be duplicated soon? The job looked feasible. Within three days, try-out models were on their way to Europe. Three weeks later, Western Electric Company had made and delivered every tube. They were plugged in; vital communications sprang to life.

Vacuum tubes are an old story for Bell Laboratories scientists. Back in 1912 they made the first effective high vacuum tube. Three years later, they demonstrated the practical possibilities of tubes by making the first radio talk across the Atlantic, pointing the way to radio broadcasting. Since then, they have developed and utilized the vacuum tube wherever it promises better telephone communication — there are more than a million in your Bell Telephone System.

Today, Bell Telephone Laboratories is solving many of the toughest tube problems faced by the Armed Forces. When the war is over, it goes back to its regular job—keeping American telephone service the best in the world.



• This electrical replica of a heater-type pentode was made for use in German telephone repeaters.

BELL TELEPHONE LABORATORIES

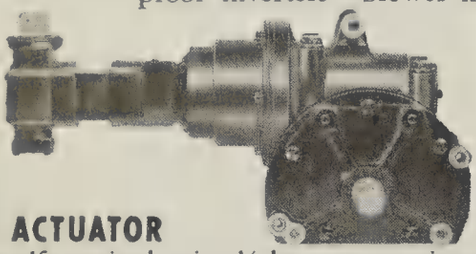
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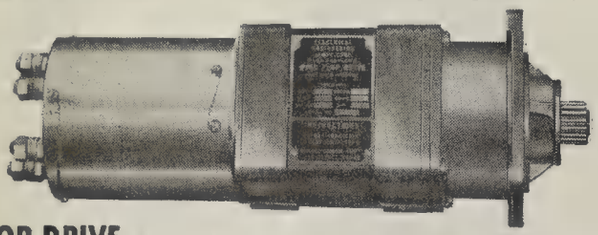
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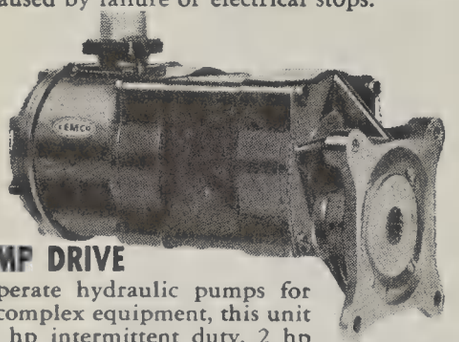
ROTARY ACTUATOR

Completely self-contained unit — ⅛ hp motor, equipped with magnetic clutch and brake — Compound planetary and worm and sector gearing provides ■ reduction of approximately 15,000 to 1 — Maximum torque on the drive shaft is 6,000-inch-pounds. Can be wound for use in a 28 volt or 32 volt system — Output speed is 5/10 rpm.



MOTOR DRIVE

An intermittent duty type, 2 hp, 7500 rpm motor — Equipped with magnetic clutch and brake — Thermally protected — Additionally protected against exposure to dust, sand or salt spray — Designed for low impact torque, to prevent damage in the event of overtravel caused by failure of electrical stops.



ELECTRIC PUMP DRIVE

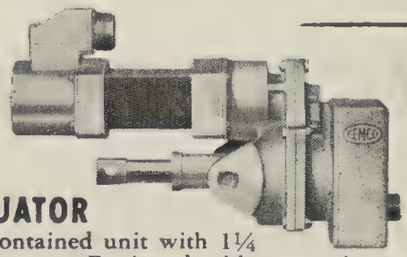
Designed to operate hydraulic pumps for power driving complex equipment, this unit consists of a 3 hp intermittent duty, 2 hp continuous duty, 9000 rpm motor — Supplied with 3.8 gear reduction — Standard AN take-off flange, and female spline take-off shaft — Weight, complete, is 12.4 pounds.



RIGHT ANGLE BLOWER DRIVE

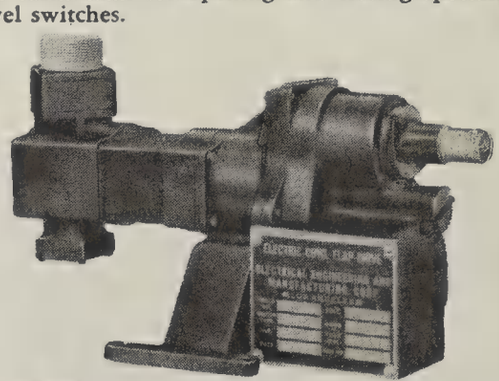
Light weight, continuous duty type, ½ hp, fan-cooled, 7000 rpm motor equipped with right angle gear box and drive shaft — Gear ratio of 1 to 1 — Overall efficiency of 70 per cent — Built for use in ■ 28 volt system — Engineered to fit extremely tight mounting conditions — Lifetime motor lubrication.

Motor designs to fit work and installation specifications as well as operating conditions — custom motor designs for aircraft — for ships — for trains — for industry — for production — for power. Submit your problem jobs to EEMCO engineers. Let the design experience of EEMCO give you motors tailored to the work for maximum efficiency, for maximum economy, for minimum trouble.



LINEAR ACTUATOR

Completely self-contained unit with 1¼ hp, 10,000 rpm motor — Equipped with magnetic clutch and brake — A double integral gear reduction unit operates screw jack actuator providing 2½" travel on the jack in less than 2 seconds, with maximum load of 3000 pounds — a control gear reduction drive turns cams for opening and closing specially developed limit travel switches.

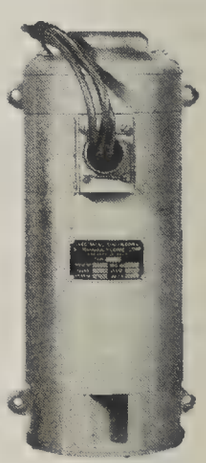


MOTOR DRIVE

Thermally protected, ⅙ hp motor — Equipped with magnetic clutch and brake — Motor actuating unit complete weighs 4¾ pounds (nearest competing weight in a motor of this type is 7 pounds) — Shaft output is 8-inch-pounds at 1200 rpm — Straight 8 to 1 gear reduction is provided for work actuation of various kinds — Double reduction and worm drive operates cams for limit motion control.



FOR PURPOSES OF INQUIRY — EEMCO engineers will gladly study all problems submitted. Please give them pertinent data regarding desired performance and operation. Cover description of application — duty cycle — kind of current — horsepower — speed — motor dimensions — mounting requirements, etc.



Sealed VAPOR PROOF MOTOR

Double enclosed 2½ hp d-c continuous duty motor — integral gear reduction of 3.8 to 1 is provided — Approximate output rpm is 2400 — Overload capacity is 150 per cent for 15 minutes — 32 or 110 volt d-c — An internal fan cooling system is an integral part of the unit.

SPLASH PROOF INVERTER

Self contained unit designed to convert 32 volt d-c current into 110 volt 60-cycle a-c current — Totally enclosed, fan-cooled model with 350 volt amperes peak capacity — Can be adapted for use with ■ power supply source of 110 volt d-c.

EEMCO

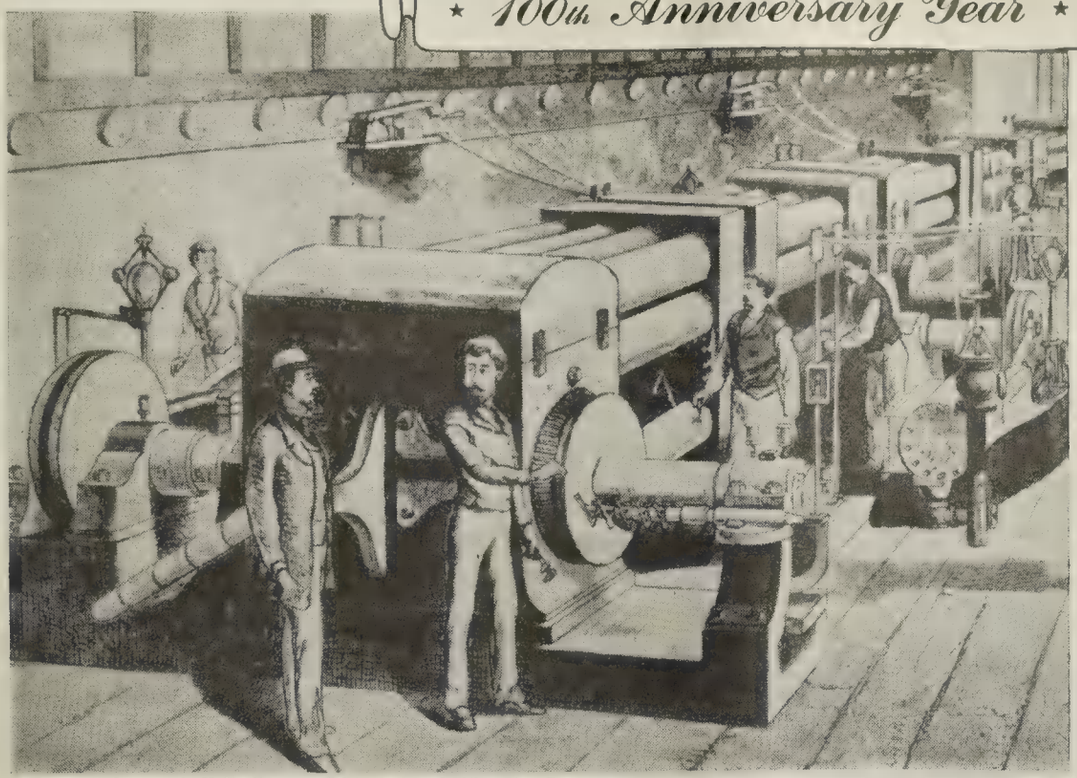
ELECTRICAL ENGINEERING AND MFG. CORP.

4606 West Jefferson Boulevard, Los Angeles 16, California

Scientific American

JUNE · 1945

* 100th Anniversary Year *





From "Men and Volts," copyright General Electric Company

Above: Dynamo room built in New York City (1882) by Edison's company to serve 14,000 incandescent lamps. Right: The future of television may lie in the development of RCA's unattended radio relay stations

100 Years of Electricity and Electronics

Less than the Span of a Single Century Covers the Lifetime of Applied Electricity. From Early Developments in an Obscure Art has Come the Science of Electronics, Taking Over Many Jobs in Industry and Doing Them Better than Ever Before. A Glimpse of the Future

By VIN ZELUFF and JOHN MARKUS

Associate Editors, ELECTRONICS

GOING BACK a hundred years, just beyond the memory of anyone living today, brings us simultaneously to the first issues of Scientific American and to the growing-pains days of electricity, when glowing electronic tubes were yet undreamed of and even the electron itself was unknown.

In 1845, horses furnished the motive power for transportation. The life of these horses was rigorous, and on the average they lived only about three years. As evening approached, lamplighters made their rounds through city streets on nights when there was no full moon. In homes the filling of kerosine lamps, trimming of wicks, and wiping of the glass chimneys was an almost daily chore. This non-electrical kind of living continued for just about 35 more years, while scientists and inventors plodded away in dingy laboratories creating the electrical foundations for the progress to come.

Even in 1880 there were no electric lights, except in the hands of a few experimenters—no electric streetcars except in the dreams of visionaries—no electricity in homes, and little anywhere else. But people did not miss these things; in fact, visitors at the Centennial Exposition in 1876 glanced at the small and unobtrusive Gramme generator supplying current to a single arc lamp and blinked at the dazzle of bluish light. "What curiosities!" they commented as they walked on to admire the giant steam engine in the next booth.

But the inventive minds of men like Brush, Thomson, and Edison kept prodding these first sputtering dynamos into more and more of the productive uses that would one day compel the steam engine to share honors with electrical power. Brush improved on the dynamo and made the carbons of the arc lamp adjust automatically to the correct distance apart, without touch of human hands. The first Brush lamps to be installed in Philadelphia, in the show windows of the John Wanamaker store, were one of the wonders of 1878 and were de-

scribed by one newspaper reporter as "miniature moons on carbon points, held captive in glass globes."

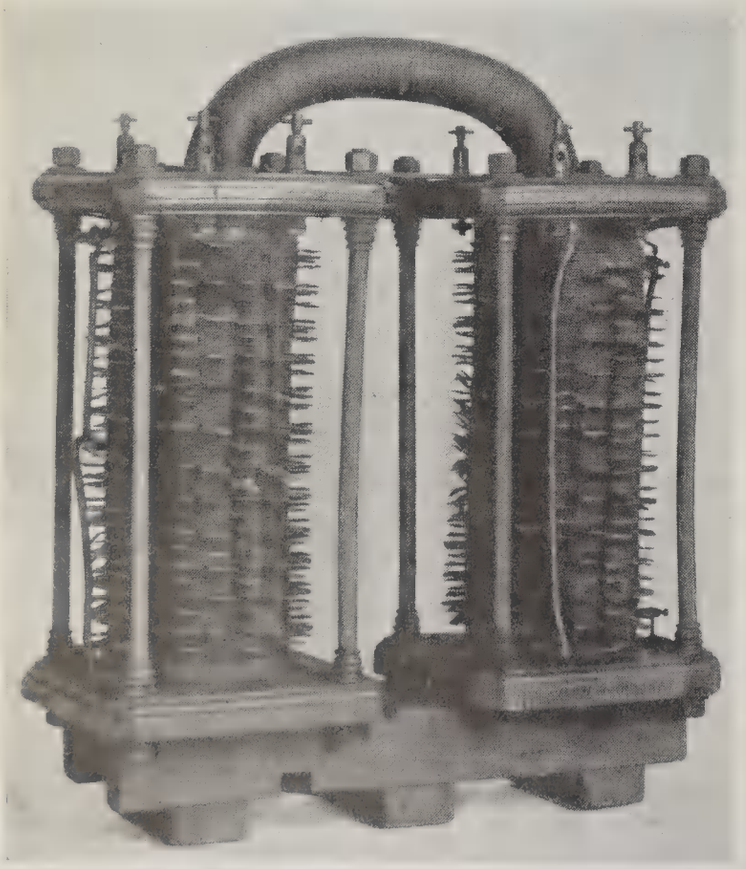
ARCS TOO BRIGHT—Elihu Thomson made the generator brushes adjust themselves automatically to changes in load, so that individual lights could be switched on and off without upsetting the balance of the circuit. But the arc lamp was too bright for home use and had many other weaknesses. Could anyone cut up its two thousand candlepower into, say, twenty lamps each equal to a hundred candles?

Thomas A. Edison thought he could. Near the end of October in 1879 he carbonized a cotton thread, bent it into a horseshoe shape and put it inside a sealed glass bulb. The current was switched on. The lamp glowed with a soft light. Half expecting the frail red horseshoe of light to vanish, he and his workers sat down to watch and wait. No one thought of eating or sleeping. A second dawn found them still at their vigil, and not until 40 hours after that lamp first received current did it burn out.

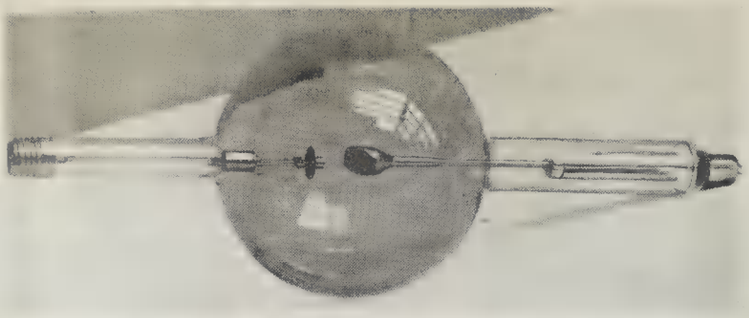
As the little lamp glowed on and on, they envisioned great cities lighted from central power stations by lamps lasting hundreds of hours. They had a lamp that could go where arc lamps were impractical—an entirely new light source to compete with gas lighting.

In city after city in the decade that followed, elaborate celebrations heralded the turning on of outdoor arc lamps for the first time. People fell on their knees at the sight, as if in the presence of the supernatural. And all this time explorers were searching the world for dense, woody growths from which better filaments could be cut for Edison's lamps. Bamboo of a certain species proved better than anything else then known. In 1881 his company sold nearly 30,000 lamps at 70 cents each.

By August 1882 Edison had wired 900 buildings in New York and placed more than 14,000 lamps in their sockets. But troubles were ever present. During a test of the system, a young man burst into the dynamo room crying: "Your electricity has got into the pavement up in Fulton Street and all the horses are dancing." An Edison crew took several days to locate the faulty buried conductors and repair the insulation that caused such mischief. The system was successful at its inaugural, however, and initiated two decades of exploitation of "dose schmall condensed lights vat comes in bottles," in the words of one newly arrived immigrant.



Forerunner of the transformer was this Gaulard and Gibbs unit brought to U.S. in 1885 by Westinghouse



By 1917, this Coolidge X-ray tube had standardized practice in a field formerly on a hit-or-miss basis

IMPROVING THE PERFECT—By 1900 many scientists were convinced that Edison's carbon filament lamp was just about perfect and doubted whether it would ever be materially improved. However, the General Electric Research Laboratory was started that year, and since then the efficiency of the lamp has been increased about sixfold!

Dr. Whitney started the investigation when the gradual blackening of the bulbs, as they were used, began to annoy him. He knew that the blackening was caused by the evaporation of carbon from the carbon filament, but he thought the rate of the blackening might be increased because the filament contained small traces of ash oxides. To reduce the undesirable oxides, he tried treating some carbon filaments in a special furnace at a much higher temperature. For the same life as prior filaments, his new lamps had 25 percent higher efficiency; at the same efficiency, they had 4¾ times the life!

Whitney's new GEM lamps were put on the market in 1905. (GEM was the name obtained from the initials of General Electric Metallized—so called because the graphite coating of the carbon filament acquired metal-like characteristics in the furnace.) GEM lamps sold for 12 years, when they were replaced by tungsten-filament lamps whose efficiency was 80 percent higher.

Dr. W. D. Coolidge initiated this next advance in lamp efficiency by developing a process for producing ductile tungsten commercially and drawing it down to a fine wire. Lamps with this tungsten filament were so strong that breakage in shipment was no longer a major problem, and the lamps at last were able to withstand the violent shudders of the automobiles of those days.

Dr. Irving Langmuir soon discovered that the blackening of lamp bulbs caused by evaporation of tungsten from the filament could be greatly reduced by filling the bulb with an inert gas at atmospheric pressure. All except the smallest-size bulbs are gas-filled today, and modern lamps generally burn out long before they would have to be discarded due to the blackening effect. The 60-watt bulb that once cost $1.75 and had an efficiency of 1.7 lumens per watt for a useful life of scarcely more than a hundred hours is today selling for only 13 cents yet has an efficiency of 13.9 lumens per watt and lasts more than 10 times as long.

BETTER X-RAYS—As soon as he succeeded in producing wrought tungsten for lamps, Coolidge turned to its application to X-ray tubes. Observing the higher melt-

ing point and heat conductivity of tungsten, he replaced the platinum target of the tubes with tungsten.

Up to this time, all X-ray tubes were dependent for their operation on the presence in them of a small amount of gas, which determined the characteristics of the tube. But, since different degrees of penetration were required for radiographing different parts of the body, X-ray technicians had to keep an assortment of tubes. Even then there was a certain amount of guesswork involved in selecting the right tube.

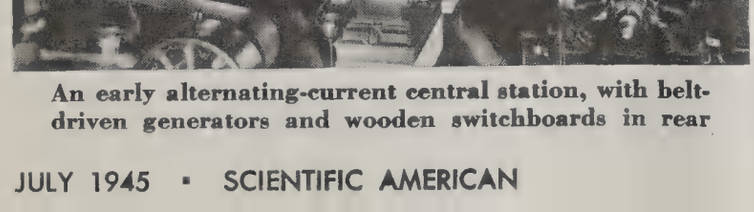
Coolidge planned to build a tube with the highest attainable vacuum and with a hot-tungsten filament replacing the cold aluminum disk as cathode. He reasoned that the electron emission depends on the temperature of the filament, so why not control the temperature of the filament by a rheostat? Coolidge tried, and it worked. By such control, he could determine the electron emission and consequently the electrical characteristics of the tube. This tube, which bears the name of its inventor, has made an exact science of the hitherto hit-or-miss X-ray practice.

Today 1,000,000-volt and 2,000,000-volt X-ray tubes peer through many inches of steel as though it were glass, and scientists are even working on billion-volt tubes.

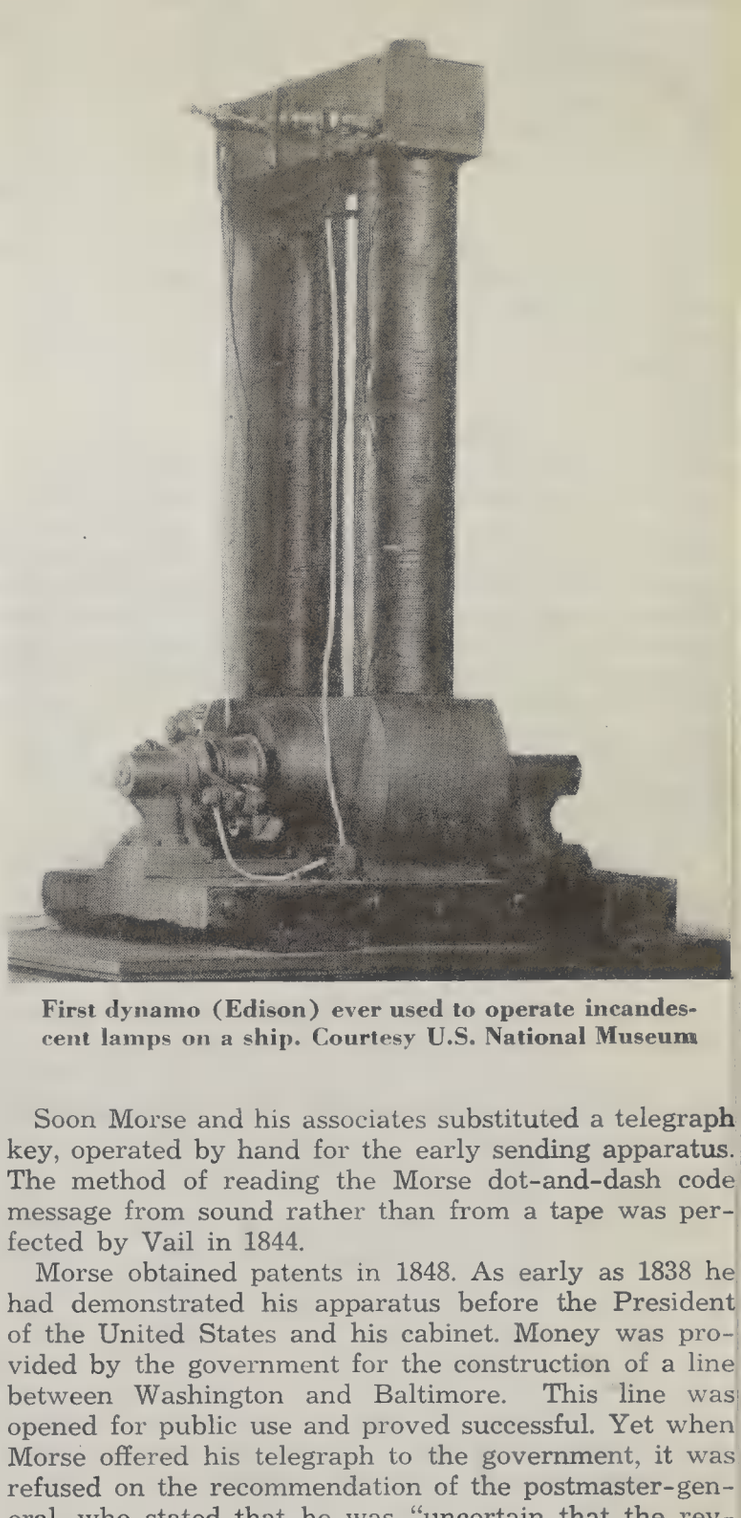
WIRE COMMUNICATION — The telegraph really started with Oersted, who in 1819 found that a magnetized needle would be deflected from its normal position when brought close to a wire carrying a current. Soon after, Ampere proposed the use of magnetic needles and coils for the reception of signals. Ampere's first telegraph system employed a pair of line wires for each character to be sent, which made it of little value.

Wheatstone and Cooke did much to popularize the telegraph and to demonstrate a system of the deflecting-needle type, requiring six line wires. It was used on railway systems, but was superseded by a type having only two line wires.

While returning from a study of art in Europe, Morse designed his first telegraph. Morse had a stylus attached to a movable armature which was actuated by the pull of an electromagnet. The stylus traced a record of the dot and dash code impulses on a moving piece of paper. About 1835, Morse privately demonstrated his telegraph and obtained the backing of Gale and Vail. These men not only obtained financial aid, but also made later improvements. The early sending switch was operated by drawing beneath it either a notched bar or a bar in which pegs were arranged in accordance with a code. Neither hand operation nor aural reception were employed at this time.



An early alternating-current central station, with belt-driven generators and wooden switchboards in rear



First dynamo (Edison) ever used to operate incandescent lamps on a ship. Courtesy U.S. National Museum

Soon Morse and his associates substituted a telegraph key, operated by hand for the early sending apparatus. The method of reading the Morse dot-and-dash code message from sound rather than from a tape was perfected by Vail in 1844.

Morse obtained patents in 1848. As early as 1838 he had demonstrated his apparatus before the President of the United States and his cabinet. Money was provided by the government for the construction of a line between Washington and Baltimore. This line was opened for public use and proved successful. Yet when Morse offered his telegraph to the government, it was refused on the recommendation of the postmaster-general, who stated that he was "uncertain that the revenues could be made to equal its expenditures."

To increase the message-carrying capacity of the line, Gintl invented the duplex system in 1853, and Heaviside in 1873 and Edison in 1874 independently invented the quadruplex system. The multiplex system was suggested by Farmer in 1852, and later developed by Meyer (1873), Baudot (1881), and Delaney (1884).

SUBMARINE CABLES—After the introduction of gutta-percha as an insulator and methods of applying it to wires had been developed, submarine cables became of commercial importance.

One of the first attempts to lay a submarine cable was made in 1850, when a cable was placed between England and France. Because of its weak construction, it broke shortly after communication was established. In 1851 a second attempt was made and this time the cable proved successful.

The first attempt to lay a cable across the Atlantic was made by Cyrus Field and his associates in 1857. It ended in complete failure. In 1858, however, a cable was successfully laid between Newfoundland and Ireland; it was operated for about three months before it failed

in deep water and could not be repaired. In 1865 an effort was made to lay another cable, but it broke when about two-thirds completed. The following year, however, a cable was laid across the ocean, and this cable proved satisfactory. Soon after, the broken end of the cable laid the previous year was picked up, and this cable was then completed. These two cables were operated without competition until 1869, when an additional cable was laid. Now there are more than 20 cables across the Atlantic between North America and Europe alone, and more than 3200 submarine telegraph cables in the entire world with a total length in 1931 exceeding 350,000 miles.

WIRELESS—In 1865, James Clerk Maxwell, utilizing the electrical and magnetic experiments developed by Faraday and Oersted, proposed that light waves were electromagnetic in character and that a charge of electricity moving through space constituted an electric current. Heinrich Hertz proved in 1888 by his experiments that Maxwell's predictions were valid. Hertz showed that radio waves move with the same speed as that of light and behave in much the same manner. He also showed that the radio waves had lengths that varied from a few inches to many miles.

With Hertz's equipment, electric waves could be detected at very short distances only. During the early nineties, however, many scientists, including Branly and Lodge, experimented with a more sensitive type of detector, to which the general name coherer was given. This instrument consisted of a glass tube containing two metal plugs with a large number of small metallic particles placed between them. When electric oscillations were passed through the coherer, the particles adhered together, and the resistance dropped. To use the instrument for the continuous detection of groups of oscillations produced by operation of the hand key it was repeatedly tapped by a hammer like that of an electric bell. This unit was called a decoherer.

With an instrument of this nature, Marconi received signals sent by electric waves over distances of several miles, and he found that the addition of an antenna system increased the range of his equipment.

The next major discovery in the field of wireless was due to Sir Oliver Lodge, who realized the importance of tuning the circuits to make them all resonate to the particular frequency of the oscillations which it was desired to send out. He did this by adjustment of the size of the coils and condensers employed. As a result of the improved sensitiveness thus attained, Marconi, in 1901 was able to detect signals in Newfoundland sent out from Cornwall, England.

In England, spark transmission was improved by the introduction of the Marconi rotating spark gap, which both decreased the rate of decay or damping of the oscillations and gave a musical note in the telephone receiver. In Germany, the Telefunken Company developed the quenched spark system, in which the same objects were achieved by means of a specially designed stationary spark gap.

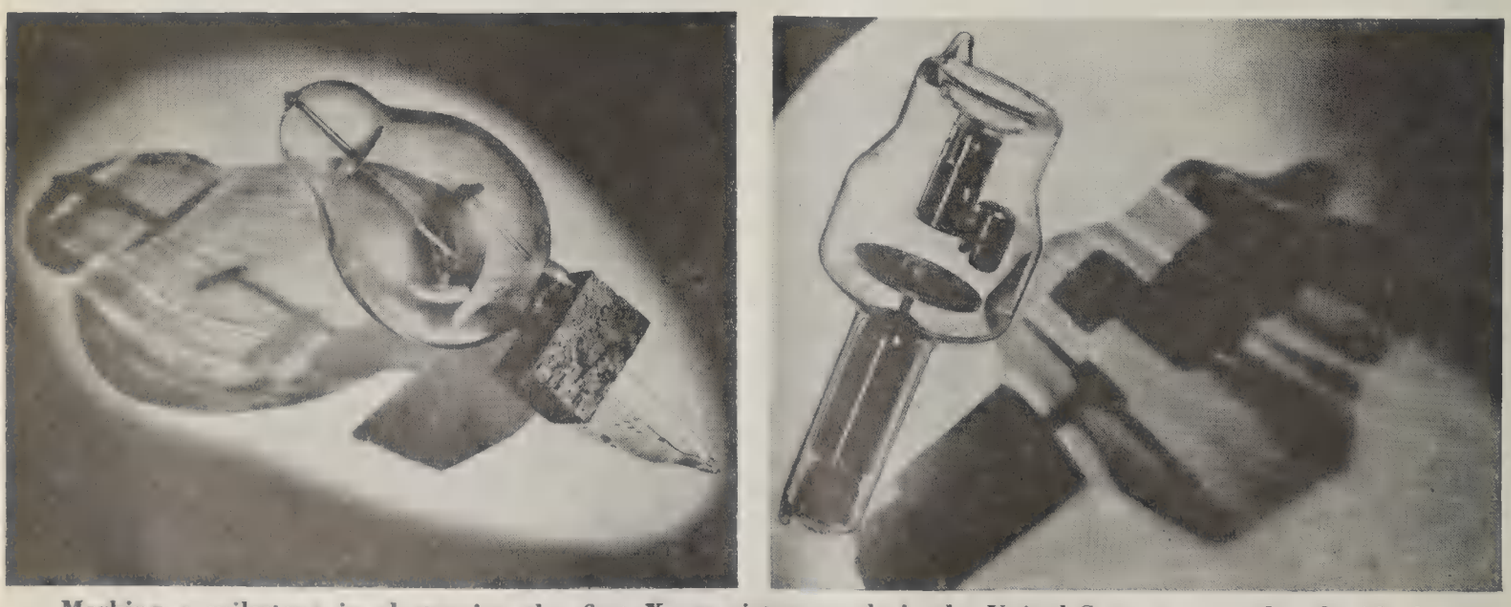
By 1912 the Marconi Company was conducting a commercial service between Clifden in Ireland and Glace Bay in Canada, and at the beginning of World War I a 300-kilowatt spark station had been completed near Carnarvon for communication with the United States. The development of radio communication between ships at sea and between ships and shore was also far advanced, and the number of lives saved by wireless at sea was already large.

Poulsen and Pedersen in Denmark developed to a considerable extent the Poulsen arc system of transmission, in which the aerial was connected to one side of an electric arc, the other side being connected to the earth. The arc system was further developed in America by C. F. Elwell, and many of the high-power arcs were installed in stations in Europe. In addition to the arc system, the design of high-frequency alternating current machines was carried to an efficient stage of development, especially by Latour in France and by Alexanderson and Goldschmidt in America. These machines were installed in many French and American high-power stations.

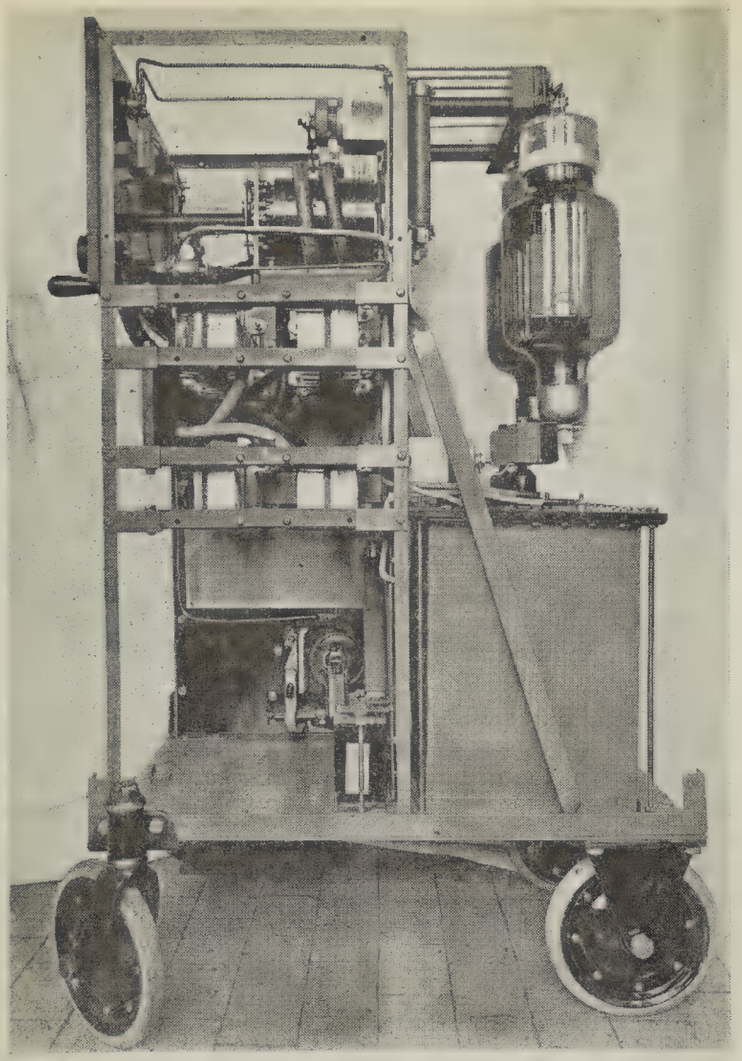
The sensitivity of the detectors of radio waves, the crystal and coherer, was very small and the search for a better instrument to convert the received energy efficiently led to the development of the vacuum tube.

EDISON EFFECT—In 1883 Thomas Edison, while conducting experiments with the incandescent lamp, noticed that if a second electrode in the form of a wire or plate was placed inside the lamp and this electrode made positive with respect to one end of the filament, a small current flowed to this electrode when the filament was heated. This is called the Edison effect and is the basis of modern electronics.

Professor J. A. Fleming of England learned of the Edison effect, and about 1896 developed a two-element radio detector tube which became known as the Fleming valve. About 1906, Dr. Lee de Forest added a third electrode, called a grid, to the vacuum tube. The vacuum



Marking a milestone in electronics, the first X-ray picture made in the United States was produced with the tube at the left above. Compare this with the modern rotating-anode tube (right) from Machlette Laboratories



High-frequency heating, now just coming into its own, was done 25 years ago with this Ajax-Northrup unit

tube was improved by further study and experimentation carried on by Dr. Langmuir and other scientists, and today there are about 1000 types in use in our radio and electronic equipment.

Mention must be made of the extremely successful experiments in radio-communication carried out by amateurs, which went a long way to show commercial engineers that possibilities were being overlooked in the short-wave region. Just prior to World War I, amateur stations which had previously been allowed longer wavelengths were subjected to a degree of control, and forced to rely solely on wavelengths below 200 meters, then considered useless for serious purposes. After the most commendable persistance and endeavor, amateur signals were first received in England from America in 1921 on wavelengths slightly below 200 meters, and by 1924 communication in both directions on shorter wavelengths and very low power had become frequent. It may be said that short-wave communication was both discovered and to some extent developed by those working essentially for the fun of it and for the advancement of science, without thought of immediate material gain.

In 1916, David Sarnoff, then assistant traffic manager of the Marconi Wireless Telegraph Company of America, proposed a "radio music box" in a memorandum to his boss: "I have in mind a plan of development which would make radio a household utility in the same sense as a piano or phonograph. The idea is to bring music into the house by wireless . . . For example, a radio telephone transmitter having a range of say 25 to 50 miles can be installed at a fixed point where instrumental or vocal music or both are produced . . . The receiver can be designed in the form of a simple 'radio music box' and arranged for several different wavelengths, which should be changeable with the throwing of a single switch or pressing of a single button . . . The same principle can be extended to numerous other fields, as for example, receiving lectures at home which can be made perfectly audible; also, events of national importance can be simultaneously announced and received. Baseball scores can be transmitted in the air by the use of one set installed at the Polo Grounds. The same would be true of other cities. This proposition would be especially interesting to farmers and others living in outlying districts removed from cities. By the purchase of a radio music box they could enjoy concerts, lectures, music, recitals, and so forth which may be going on in the nearest city within their radius . . . Should this plan materialize, it would seem reasonable to expect sales of 1,000,000 radio music boxes within a period of three years."

Today, as president of Radio Corporation of America, David Sarnoff sees his memo-dream fulfilled and expanded many times, with the vast potentialities of electronics swiftly unfolding from its nucleus of radio.

Thirty years ago, De Forest's three-electrode tube was applied as a repeater on the telephone wire circuits connecting New York and San Francisco, making transcontinental telephony possible and practical. In wire telephony and telegraphy, as well as in radio, electronic applications provide a basic means from which successive developments are made to meet the communications needs of expanding industry and national activity.

Now, radiotelegraph circuits over distances in excess of 5000 miles operate at transmitting speeds of more than 500 words per minute. Electronics has made possible short-wave teletype circuits which reach practically any part of the world and radiophoto services in which pictures taken on the battlefields of Europe or in the Pacific are brought, within a few hours, to our daily newspapers. Regular radiophone service is available to the remotest sections of the globe, and radiotelegraph and telephone services even extend to ships and planes almost anywhere.

Radiograms are not broadcast in the sense that they can be picked up by the general public. Directive aerials project the transmitted energy toward the desired receiving terminal in the form of a concentrated beam, somewhat analogous to the beam of a searchlight. High-speed automatic transmitters are used and the messages can be recorded only by special receiving apparatus. Simultaneous transmission of two or more messages on a single radio channel — known as multiplexing — results in effective scrambling of the radio code message, which can be detected or unscrambled only by special synchronized equipment.

TELEVISION—In the early 1930's there was developed in the laboratories of Radio Corporation of America an all-electronic television system that made use of Dr. Vladimir K. Zworykin's iconoscope, a tube employing electronic scanning to convert the light image into an electrical signal. Development of this system continued in the laboratories for several years, and in 1936 was given field tests. A hundred television receivers were built for installation in the homes of RCA engineers and executives, and a transmitter was installed in the tower of the Empire State Building. The tests were successful, and in 1939 limited commercial television broadcasting was authorized by the Federal Communications Commission.

Other organizations were also conducting experiments during the above period, and there naturally arose some differences of opinion among engineers as to technical details such as the required number of scanning lines, systems of synchronization, and so on.

These differences were reconciled and standards established by a committee of engineers in 1941. The Commission adopted the committee recommendations and authorized commercial television broadcasting to start on July 1, 1941. Had it not been for the advent of the war, television would be well on its way as a national service.

RADAR—From radio and television came radar, used by static ground defenses and on warships to detect the approach of enemy aircraft and ships at night or through cloud cover, to determine the distance (range) to the enemies' forces, and to provide data for anti-aircraft guns.

In the Battle of Britain, equivalent British radio locators spotted German raiders long before they reached a target area, and thus gave the RAF and ground defenses time for preparation. On a stormy night off Guadalcanal on May 31, 1943, one of our ships sank a Japanese battleship miles away with its second salvo, using only radar to direct the guns.

On December 7, 1941, the Army's radar at Pearl Harbor, with Private Joseph L. Lockard on duty, detected planes approaching, and located them about a half hour distant from the Hawaiian Islands. His superior officer, knowing that a number of American planes were due from the mainland, took no action. Although radar's warning went unheeded, its signal summoned America to the most tremendous undertaking in its national history.

Like many electronic inventions, radar is attributed to no one inventor. It draws upon many radio devices and circuits, and therefore many scientists contributed to its development. The basic principle of radar — radio reflection — is as old as radio itself, but it was not harnessed until we had to find an anti-warplane device.

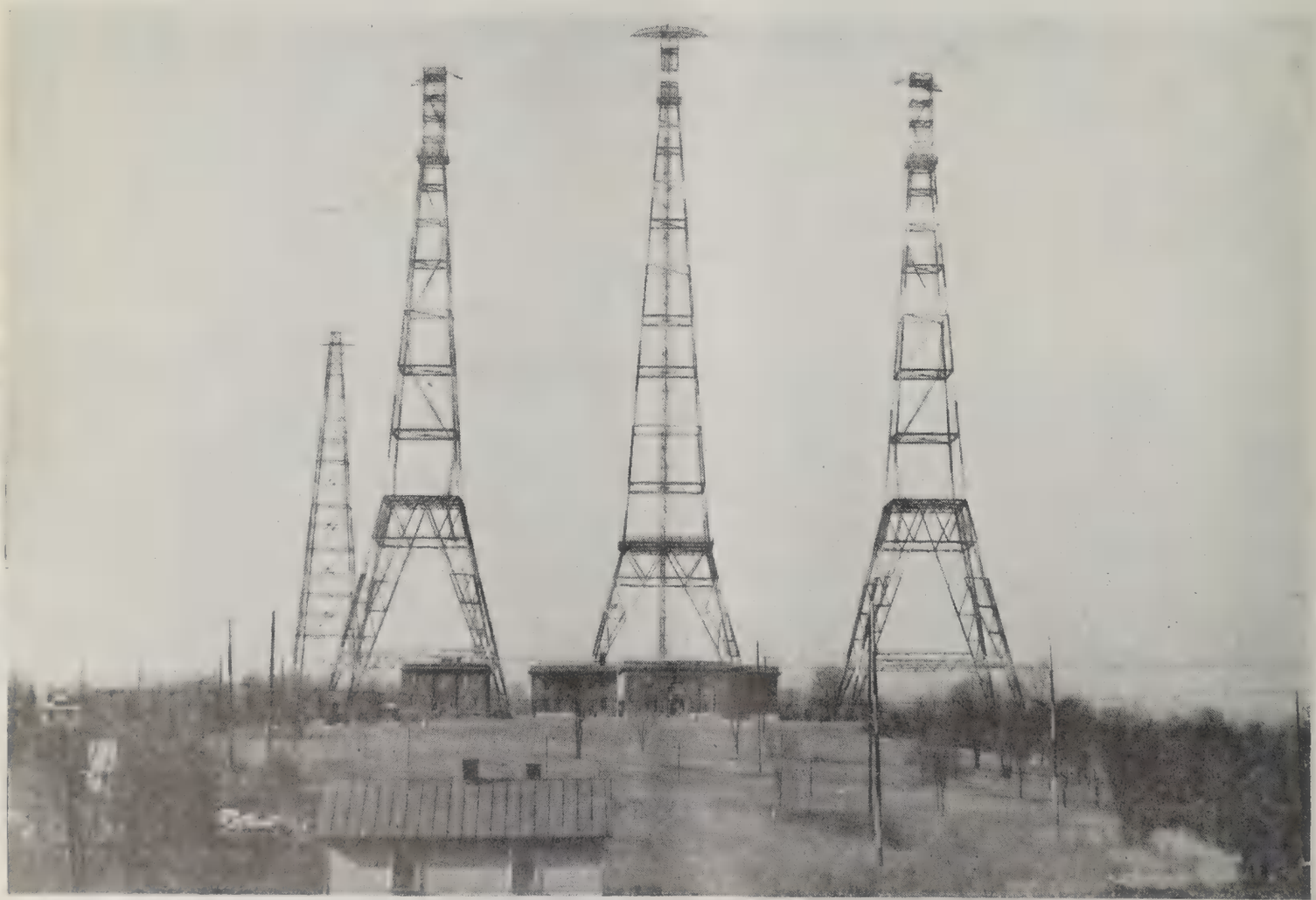
When Hertz demonstrated that electromagnetic waves could be reflected, he was far ahead of his time in radar. But it remained for Tesla to recognize and to point out the practical application of the radio echo:

"I have sent electrical vibrations toward the remote boundaries of the earth, and the earth has replied. In place of an echo I have obtained a stationary electrical wave—a wave reflected from afar. Stationary waves . . . mean something more than telegraphy without wires to any distance . . . For instance, by their use we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed."

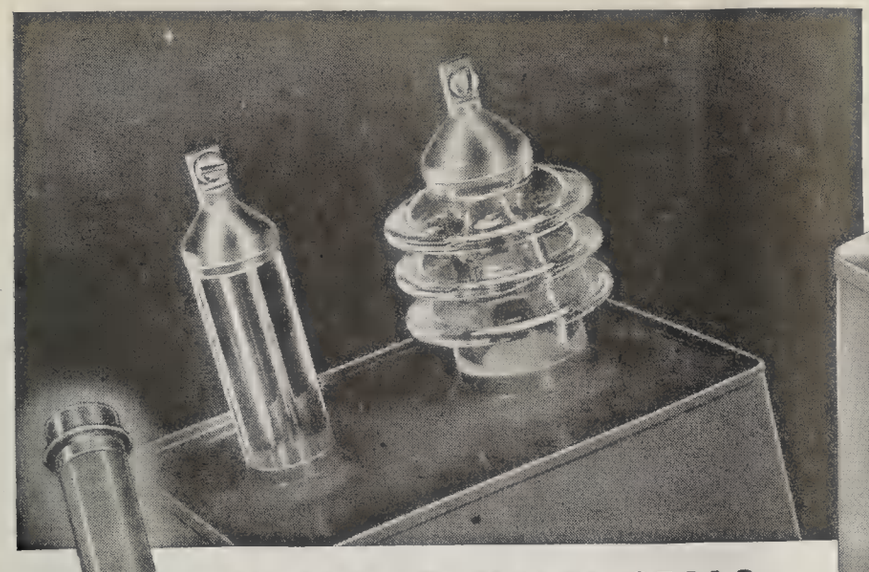
In the battle of Attu in Alaska, when our forces arrived and wanted to get men ashore in small boats, the weather made visibility so bad that the water could not be seen from the deck of a ship. The ships were berthed and the men landed by the use of radar.

A radar-controlled anti-aircraft searchlight, recently displayed by the Army Service Forces, synchronizes the beam of a powerful field searchlight with movements of the target. The equipment requires three operators seated at a tent-covered control board on which are four circular cathode-ray screens. The two large screens or scopes indicate the location of the airplane and the two smaller scopes give the distance or range, in terms of spacing between two bumps or pips in the pattern traced by the electron beam on the screen. A highly mobile concave radar antenna is mounted atop the control board and is simultaneously aimed with the searchlight by means of hand wheels on the control board. When both antenna and searchlight are on the target, the searchlight automatically goes on and its beam intercepts the aircraft.

Other radar equipment recently displayed includes an early model portable radar warning set. Its direction-finding antenna consists of a large number of small wire antenna arranged in a concave pattern to give

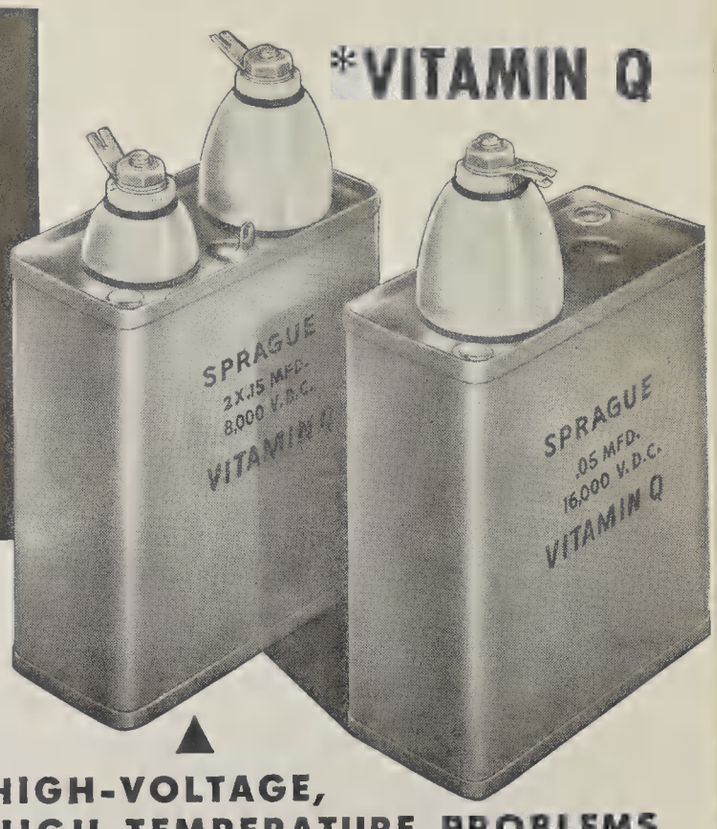


Towers of the famous radio station at Arlington, Virginia, that played a vital part in World War I communications



GLASS-TO-METAL SEALS

The old problem of protecting various capacitor and resistor types against leaks and moisture is solved by a unique glass-to-metal seal pioneered and perfected by Sprague. Glass capacitor bushings are sealed direct to the metal container and do not require adjacent metal rings with "matched" coefficients of expansion. On Sprague *KOOLOHM Resistors, the units are encased in glass tubes which are sealed directly to the metal ends. The resulting seals are leak proof, shock-proof, humidity-proof, and fungus-proof.



*VITAMIN Q

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When you've got both high voltage and high temperature to contend with in a capacitor application—well, ordinarily, you'd have a problem on your hands. Once again, however, Sprague engineering supplies the answer. Although extremely compact, Sprague Capacitors impregnated with *VITAMIN Q operate satisfactorily at thousands of volts at ambients as high as 105° C. Leakage resistance at room temperature is 20,000 megohms for one microfarad, or at least five times better than previous types!

A Step Ahead!

Sprague engineering progressiveness is no better exemplified than by the three outstanding achievements depicted here. And remember, such developments are only the high spots! Equally important is the fact that similar, if less startling, engineering superiority is evidenced in every one of the hundreds of Sprague Capacitor and *Koolohm Resistor types that are regularly produced. Even small points of departure from the conventional often make a startling improvement in results—and no type or design produced by Sprague is so humble as to fail to receive regular engineering attention in a constant effort to surpass for Tomorrow that which is "best" Today.

SPRAGUE ELECTRIC COMPANY
North Adams, Mass.



PERMITS 200° C. CONTINUOUS OPERATION

Many types of electrical equipment can now be designed for 200° C. continuous operation, thanks to the Sprague wartime development of *CEROC 200, a flexible ceramic (inorganic) insulation for copper, nickel, and other types of wire. Smaller equipment can be designed to do bigger jobs. *CEROC 200 dissipates heat rapidly and has an extremely good space factor. You'll be hearing a lot about *CEROC 200 in days to come!

*Trademarks Reg. U. S. Pat. Off.

SPRAGUE

PIONEERS OF RADIO-ELECTRONIC PROGRESS

beam action. With the controls in the portable set are two scopes, indicating the position of the plane in relation to the set. This instrument, now obsolete, was capable of locating a medium bomber up to 100 miles away.

Heavier radar anti-aircraft apparatus automatically controls gun range. This, however, is a massive piece of field equipment. The entire equipment, including the antenna structure and the three operators, moves as a unit and can be turned in all directions.

Revealed at last is the mystery of how Allied bombers have been able to drop their bombs accurately on invisible targets through the thickest clouds, smoke, or darkness. The electronic device that does this is called "Mickey" and is a form of radar that allows airmen to see on the screen of the scope distinctive outlines corresponding clearly to landmarks far below. A trained operator watching the scope can readily distinguish the line between land and water, as required in the bombing of most large cities since they have river or coastal frontage. In effect, Mickey gives a profile of the terrain below, and can be focused to get an increasingly sharper picture of limited areas such as an industrial area or even a specific building.

On D-day in Normandy Mickey enabled bombers to find their beach targets through an overcast and also located landing places for air-borne troops in the darkness. As in radar, a signal is sent back by the invisible target like an echo and is translated electronically to an image that is a reproduction of the ground below. Water shows up as dark patches, while buildings are lighter patches having the same shape as the actual structures on the ground.

Not all planes in a bombing mission need to carry radar, which is fortunate because the equipment is quite bulky and therefore reduces the bomb load. One tactical procedure involves using a pathfinder plane to locate the target by radar and drop on it one or more colored smoke bombs that allow succeeding waves of planes to sight the smoke columns from as far as five miles off and release their bombs over the target.

The letters of the word "radar" spell the same forward and backward, with *ra* standing for radio, *d* for detection, *a* for and, and *r* for ranging. The fact that radar involves a backward reflecting echo is apparently just a coincidence with the reversible spelling.



Bell Telephone Laboratories installed this Ajax induction furnace for experimental alloy work in 1919



Courtesy Westinghouse Electric Corporation

A method of concentrating low-grade ores electronically may prove applicable to other concentration jobs

Although radio-controlled bombs are still in the fantastic-invention category as far as the general public is concerned, the Army Service Forces recently displayed to the press a radio system that is capable of detonating mines at distances up to eight miles on land and up to 20 miles underwater. When the mine is laid it is assigned a definite radio frequency of its own. By means of a telephone dial attached to a radio transmitter, the operator can dial a three-digit number corresponding to that assigned to the mine to be set off. Over 21,000 combinations of code pulses are available for this radio detonator system.

Electronics was born of research. However, many of the more common electronic phenomena were discovered before there was a definite knowledge of the mechanisms involved. X-rays, accidentally discovered at the end of the last century, were so named because Roentgen could not explain the action. Electron emissions were discovered accidentally and independently by Edison and others. Photoelectric effects were discovered in 1887 when Hertz showed that ultra-violet light would lower the breakdown voltage of a spark gap, and it wasn't until 1899 that J. J. Thomson identified photoelectric emissions as electronic in character. Research brought radio, which is at one and the same time the forerunner of electronics and one of the major branches of electronics.

INDUSTRIAL ELECTRONICS—Just as electronics has revolutionized warfare, so has it affected industry. Electron tubes have brought a new meaning to the word "automatic" in mechanical and electrical operations. No task is too heavy, too fast, or too precise for the electron tube. It opens doors, brings elevators to a level landing, operates timing devices, and rings alarms. It is used for smoke, fume, and fire detection. As an electronic eye it analyzes, sorts, weighs, inspects, and detects flaws as well as foreign material; it counts hundreds of items from ball bearings and beans to packages and automobiles, matches colors, gages the

YOU SEE THESE

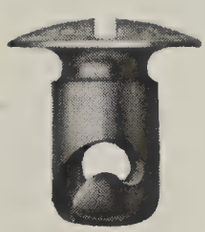
Everywhere

and here is why—

Wherever quick access is necessary on hinged or removable parts, the Dzus* spiral cam fastener is used. This strong, dependable, easy-to-operate fastener is quickly opened or closed in a quarter turn.

Dzus fasteners were introduced over 12 years ago and became widely used in the aviation industry for firmly holding engine cowls, accessory doors, plates and panels. Then other industries followed suit and adopted this type of fastener for various other fastening problems.

If you have a fastening problem, send for our catalog today. There is a Dzus spiral cam fastener for every requirement.



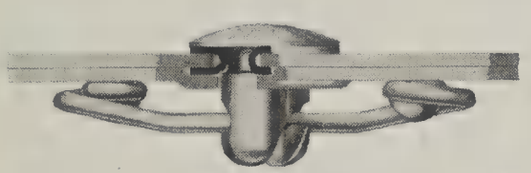
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Complete assembly of the Dzus spiral cam fastener

*The word DZUS is the registered trade mark of the Dzus Fastener Co., Inc.

DZUS FASTENER CO., INC.

BABYLON NEW YORK

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thickness of materials to a millionth of an inch, and marks time to the millionth of a second. It measures humidity and atmospheric pressure, and controls temperatures. It detects the presence of solids no human eye can see and gases no human nose can smell.

The capabilities of electronics for good or evil depend solely on the morals of those who employ them. The tubes can hear, see, feel, taste, smell, remember, calculate, and talk. They are the electronic brain not only of radio, but of industry. By the use of the electron tube, production is accelerated, power converted, work made more precise, safety enhanced, and machinery and processes controlled automatically, thus offering a wide new field for electronic engineering and electronic devices.

In electronic heating, one of the most promising industrial developments, radio waves are passed through objects such as wood, metal, and even foods and cloth to generate heat for gluing, drying, case hardening, annealing, riveting, welding, melting of metals, deactivating enzymes, and sewing of special plastics fabrics. In the processing of laminated wooden propellors electronics sets the glue in minutes instead of hours required by the steam process. Large rubber wheels are cured in 18 minutes by the electronic process while steam requires five hours. In the textile industry, rayon cakes are being dried uniformly in a matter of minutes compared with hours required by standard heating methods.

Supersonics, the application of high-frequency sounds by means of electronic equipment, has important possibilities in chemistry, metallurgy, medicine, and other fields, such as separating water from crude oil by means of vibration. Supersonic precipitation of dust and smoke and the purification of water are promising. Certain bacteria can be destroyed by intense vibrations. Degassing of molten iron to prevent holes is another possibility, and studies are being made in aging whiskey and other alcoholic products by the high-intensity vibration treatment.

ORE SEPARATION —A new electronic ore separator developed by Westinghouse Research Laboratories has successfully refined ores of such metals as tin, iron, and gold. The operating principle is much like that of the Westinghouse Precipitron that has been used for many years to remove smoke, dust, and liquid particles from air. Most promising results have been attained with low-grade ore samples from a recently developed tin deposit in a southern state. By spraying electrical charges on this ore, which contained only one and one-half percent tin, the new Westinghouse device separated the metal from rock and sand, concentrating it into an ore containing approximately 70 percent tin—suitable for smelting.

The ore is ground to the fineness of sand, dried, and then poured into a trough at the top of the separator. The particles of sand, rock, and tin trickle onto a rotating metal drum, where they receive high-voltage electrical charges from a series of fine wires a short distance from the drum's surface. Since the tin particles are good conductors of electricity, the electrical charges seep through them and into the metal drum. The tin particles then lose their charges before the drum has made more than one half turn and fall off the drum. But the poorer conducting sand and rock particles retain their charges and cling to the drum until pulled off—during the second half revolution—by a series of opposite charged wires.

The electrostatic separator can sort mixtures of any two materials provided one component is a conductor of electricity and the other such a poor conductor that it is in effect an insulator. In addition to experiments with low-grade tin and other ores, the machine may be used to separate foreign materials from grains, separate stems from raisins, and purify many types of foods.



One of the first three-element vacuum tubes of the type that was invented by Dr. Lee de Forest in 1906

DAYS AHEAD—Today radio is no longer just crooners, baseball games, and music while you shave. It is mobile police protection at all hours, weather observer, automatic pilot, instant communication for fireboat and fire truck. It is operator of remote power stations, fire fighter, and cradle watcher. It has learned to serve as well as to amuse and educate. Tomorrow, when the thunder and pain and preoccupation of war have passed, radio — released from the manacles of static by frequency modulation (FM) and stripped of its blinders by television—will bring you the clear high note of the violin, the timber of the voice, and perhaps even the color of the umpire's tie. Electronics has in store for millions of homes of the future a radio performance that as yet has not been a part of their experience.

Of electronics' part in the war only a little has been revealed, but much will soon be written. While war with one hand withholds and obstructs peaceful scientific progress, with the other it actually pushes forward industrial research and application.

Under the lash of necessity, developments which might have taken years are compressed into months. The world will reap these fruits of war, and they will not be bitter. In the words of Prime Minister Winston Churchill: "We may be astonished at the progress in efficiency we shall suddenly find displayed . . . The ceaseless improvements in wireless and the wonders of radio-locators applied to the arts of peace will employ the radio industry . . . . With the modern methods of locomotion and the modern amusements of the cinema and wireless, to which will soon be added television, life in the country and on the land ought to compete in attractiveness with life in the great cities."

Before the invention of electronic tubes, electrical engineering was largely a science of wires and circuits. We were concerned with the jars and bottles and pipes in which electricity was stored, through which it was distributed. Now, with the electron tube, the engineer can command electrons so that they will do his bidding. For the first time he has command of electricity itself—not just of its manifestations. All that has gone before, important as it has been to our lives and fortunes, may well be only a preparation for a new and greater adventure in living.



The Television Dream That Cables Make Possible

TELEVISION—sign and symbol of the age to come—is one of the wonders that specially designed cable transmission makes practical. For the quality and fidelity of the transmitted image depend largely on how well the cables are engineered and manufactured, from tiny cables in the broadcasting mechanism itself to the great coaxial cables linking city with city, making possible the television networks of the future.

Thus the "wireless age" as it develops will actually need more wires—and more complicated cables—to achieve its realization! And in the solution of these problems, new and more complicated cables will be required.

Today, we will undertake to engineer and manufacture the radio and audio cable requirements of any government agency or private concern in war work. Moreover, we look forward to solving many of the most difficult cable tasks in peacetime—as we have in wartime. The same laboratories, the same Yankee ingenuity that have helped to whip many of the difficulties involved in the communications requirements of our Army and Navy are prepared to function for industry—whatever the problems of today and tomorrow.

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

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—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

It Pays To Listen

Wire-Recording Equipment and Other Electronic Instruments are Giving New Ears to Factory Men. New Accuracies in Machine and Process Industries, Made Possible by Studying and Comparing Noises, Are Speeding Production, Improving Quality, and Cutting Costs

ONE of the latest tricks in industry is to install a microphone beside a large press which is just being set up. The microphone is connected to an instrument which records on a moving wire every noise the press makes when in operation.

The reason for all this is as old as the world of machinery and as simple as the whetting of a scythe. There is a characteristic noise peculiar to each machine which is working at its best. Tiny differences in machine and die settings will make sounds which betray them. Let those differences go undetected and the dies may fail many hours or even days before they would if perfectly set up. And die failures mean days of down time for the press while new or spare dies are installed—the wait is longer if there is only one set of dies which must be repaired before setting up the machine again.

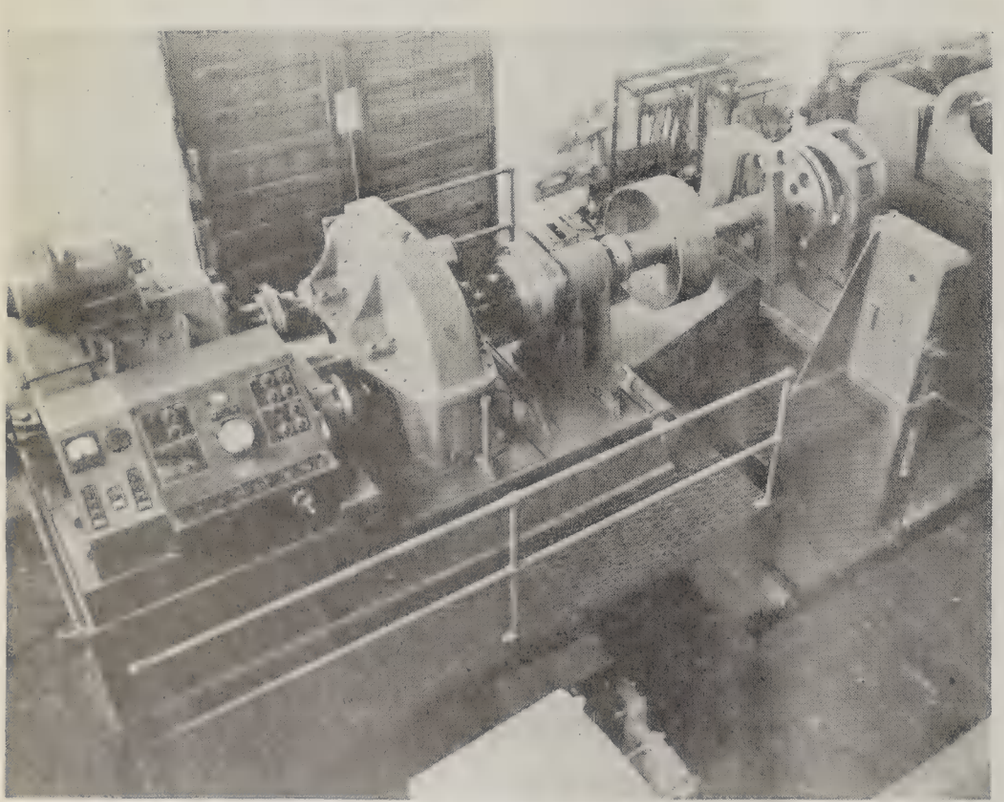
Once the machine has recorded its present noises on the wire, that wire is taken to a quiet room and played back through a standard radio amplifier and loudspeaker. Recorded on another portion of the same wire is the noise which the machine made on the set-up which resulted in the longest die life. The two are compared and the new set-up is corrected until the machine makes very nearly the same noise as it did with its most successful set-up.

Side by side with this noise inspection goes the usual microscopic inspection of the surfaces of the finished steel parts made on the press. The metallurgical laboratory still checks up the effects of the drawing operation on the grain structure of the steel parts. The comparison of the noises made by the press is just one more refinement of a highly exact setting-up process. The whole process results in longer lives for dies, higher overall operating rate of the press, more work done per operating month, better surface finishes on more accurate finished parts.

Sooner or later, of course, a more successful set-up than the "best known" one will be obtained. Then the standard set-up noises will be wiped off the wire and the new standard substituted. The whole noise-recording process is magnetic and the wire is not cut or marred by it. Hence the same wire can be wiped off magnetically and used for new recordings thousands of times.

The wire recording and repeating device is an electronic instrument. It is one of the means of giving his ears back to the factory supervisor; a process in which many instruments must serve.

The old-fashioned factory man had little need for such instruments. All around him milling machines moaned, shapers grunted, electric motors whined, heavily laden rough-toothed gears roared, belts squealed when being shifted, tumbling barrels rattled, saws sang, presses pounded. And to him every noise had a definite note, a definite meaning which could be interpreted. Although he might seem a little deaf when conversing in a quiet room, once he entered his factory he became a Stokowski and the machines were his symphony. At the slightest sour note he made corrections.



Courtesy General Electric Company

An adjustable-voltage drive with electronic control of acceleration is installed on this large dynamic balancing machine. The control panel may be seen at the left

CHARACTERISTIC SILENCES — Quietness entered factories slowly. The first of it came from the higher accuracies of high-speed machinery. A high RPM centrifugal pump cannot be allowed to make the pound-



Magnetic wire recorders, first brought into wide use for military needs, are finding many industrial applications

ing noises of the much larger but slower reciprocating ones; it soon would pound itself to pieces if it had any parts loose or ill-fitting enough to produce such noises. Ball bearings seldom can keep their high accuracies on poorly balanced, noisy equipment; motors which whine are likely to wear out quickly under heavy loads at high speeds; any machine tool which moans or grunts is wearing out its tools and bearings too fast as well as leaving chatter patterns on the finished work; gears that roar cannot carry modern high-speed heavy loads within the small spaces now alloted to gearing. Modern machines, instead of having characteristic noises, have characteristic silences.

Guarding and shielding brought more silence. Modern high-speed parts cannot be left unshielded. They are too dangerous, their lubricants will be thrown too fast and far, their delicate accuracies will be damaged by dirt unless they are enclosed.

The first guards actually increased the factory noises; they acted like drums. But modern guards have stopped all that; they stop noises and dampen vibrations.

Silence for its own sake came later. Managements noticed that heavy, noisy, slow-acting machines slowed down the working paces of men. The operators kept time to those machines as if marching to music. Other managements found that a prolonged noise also slowed down the men and promoted accidents.

Vibration absorbing pads, some of them four feet thick, were put beneath heavy presses. They reduced repair bills and increased the quality of the work as well as reduced the noise for the sake of nearby personnel. Floors, walls, and ceilings were made noise absorbent. Noisy machines and departments were enclosed. Soon, many a busy factory became as quiet as a hospital.

But while all this was going on the factory man began to miss his tell-tale noises. He had to have them back, and in sharper, more definitely identifiable forms.

INSTRUMENTS THE ANSWER—The production manager of a plastics factory had been accustomed to listening to his old-style steam traps every day. If the traps were working then he was getting wet steam but no free water at his moulding dies. If they were not working, it meant production troubles plus rusting of pipes and of die interiors.

New and more efficient traps did not make any noises that he could hear with his naked ear. A physician's stethoscope helped some, but brought wisecracking comments from the employees. The final answer was a portable microphone which amplified the noises so highly that any of his well-trained assistants can use it. His steam traps used to be one of his daily worries; now he has dismissed them from his mind.

The highly skilled tool maker who grinds small broaches to accuracies of one hundred thousandths of an inch, complained that vibrations in the tool room were spoiling his work.

His machine was moved to a vibration-free room. Still his troubles continued.

Then it was found that what he needed was not less noise but more of more identifiable noise. His vibration-free room was completely sound proofed so there would be no reverberations from the floor, walls, or ceiling. Then an electrical noise magnifying instrument was attached to the tail stock of the grinding lathe. Now the noise of his machine tells him when he is likely to run into trouble even before such trouble is shown up by his highest accuracy dial gages and tool maker's microscope.



Courtesy Western Electric Company

An electronic "stethoscope" being used to test refrigerator units. This device produces a permanent charted record of the sound level at each frequency passed

Super-accurate gearing needed noise amplification in the inspection room. Gear teeth were being finished to the highest obtainable accuracies and with surfaces smooth within eight millionths of an inch—some had been made smooth within one millionth of an inch but it was found that lubrication would not work correctly on such smooth surfaces. Even with all this accuracy it was found that some trains of gears would fail for lack of accuracy while others would not.

With instruments which depend upon light waves and upon contact doing all they could to find inaccuracies which caused the failures, some other testing means had to be tried.

A noise testing machine was devised. Characteristic noises of the running trains of gears quickly isolated the edge squeal which indicated that the leading edges of teeth were giving trouble, the knocks from the impacts of irregular teeth, the rattles from variations of helix

angles, the whines and squeals and other noises of strut or wedging action and of tip interference, the rattles from inaccurate bearings. But strangely enough it was found that many noises came from teeth which were as accurate as human means could make them but whose inaccuracies nevertheless combined with each other to produce bad running conditions. Consequently it was decided that, in spite of highest accuracies in cutting the gears, it would be necessary to devise some method of selective assembly of gear trains so as to combine gears whose inaccuracies would offset each other rather than act cumulatively.

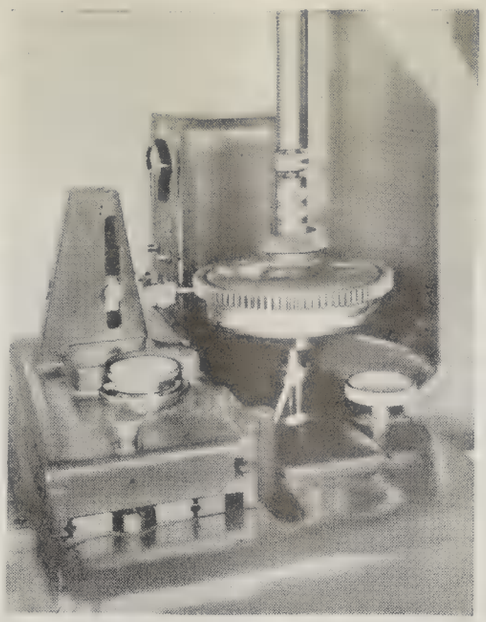
Quiet gear trains have the longest lives under the severest loads at the highest speeds, and they need little or no breaking in or running in. Noisy trains fail quickly—but it takes a specially designed machine to hear any noise at all.

In this technique the gear makers are simply borrowing an old practice of the ball bearings industry. After ball bearings have been made as accurate as machinery and testing can make them, noise testing will find defective ones. Take a noisy bearing apart, and only very rarely can instruments measure the inaccuracy which caused the noise. Reassemble these parts with others to make new bearings and the minute inaccuracies—measurable only in millionths of an inch if measurable at all—may so balance each other that the bearings will be quiet. And yet the noisy bearings on the testing machine sounded like a flat wheeled freight train going at high speed over a loose trestle while the quiet bearings made only slight swishing sounds.

THEY KNOW BY NOISE—Quite different from these testings for highest accuracies are some of the noise detection methods in use in process industries. One fermentation vat, for example, used to be open at the top and its contents were allowed to assume whatever temperature the process produced. In those days it was easy for skilled men to listen to the noises made by bubbles of gas rising to the surface and to judge by this whether or not the vat contents should be stirred.

Now the vat is totally enclosed, and its temperature is carefully regulated to control the rate of fermentation. Analysis of the gasses given off can tell a great deal about the progress of the fermentation. But noise is still the final test.

Differing from the old practice of having a trained man climb to the top of the vat and listen attentively for delicate nuances in the noises, the modern electrical microphones make the rising gas bubbles sound like the roar of Niagara—the instrument brings out enough noise so the state of the process is easy for ordinarily trained ears to detect.



Electronically operated, this General Electric profile gage is used with a Fellows involute measuring machine to record on a paper chart inaccuracies in gear teeth as minute as .0001 inch

Judging the exact time that materials should remain in processing barrels used to be a matter of instinct and guesswork. Now instruments magnify the noises made by the cascading materials and tell the whole story. Noise detectors will warn of the presence of slightly wet steam in turbines intended only for dry steam—the wet steam erodes the blading if not corrected.

Strangely enough, noise detectors also are used to tell when there is too much quiet. In a battery of inter-connected Diesel engines, for example, one engine can cut out but continue to revolve and to run fuel through its cylinders until its lowered temperature tells the story. But a noise-detecting instrument in the room will instantly react to the changed level in the total volume of sound, and the engineer can find out which engine is wrong long before its temperature drops appreciably.

These contributions of electronics to industry are certain to increase in value. There can be no point in reducing plant lighting; therefore the engineer will always have his eyes. And as the noise level is reduced, electrical instruments give him back his ears.

BUCKLED PLATES

Prevented by Applying More Heat for Shorter Time

A RAPIDLY advancing technique in arc welding is to use larger electrodes on steel plates and other thin sections and thus apply more total welding heat but apply it to any one section for a shorter length of time.

The purpose is to prevent buckling of the thin sections. And the technique contradicts a time-honored theory that the greater the total heat the greater the buckling. Evidently, buckling is promoted more by giving heat time to build up so that there are large bodies of hot and expanded metal which later must cool and shrink than by applying more heat in a shorter time and thus heating smaller areas of metal to temperatures high enough to cause trouble.

PLANT LAYOUTS

Easily Made With Scale Models

THE CLASSIC method for making plant layouts is to draw scale diagrams of floor spaces, make cardboard pieces representing the machines and equipment reduced to the same scale as the floor plan, and, after moving the pieces about on the diagram until a satisfactory arrangement is found, reduce the final layout to a blue print.



A Westinghouse model plant layout

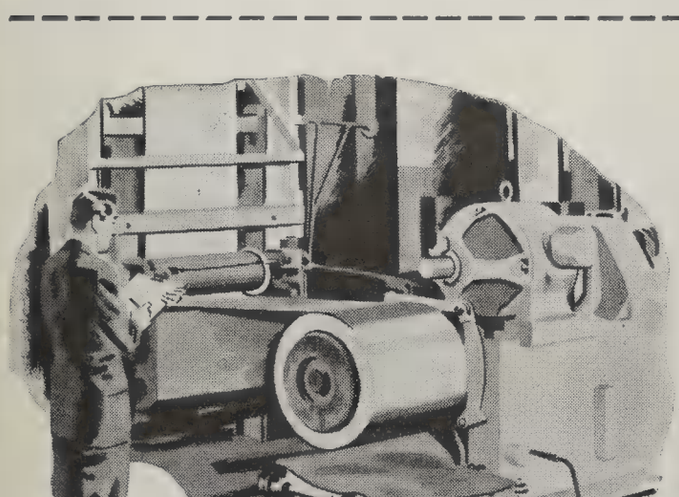
A newer method calls for making scale models of the machines, the conveyors, and other equipment. These provide a much better mental picture of how the new plant will look and how the production line will be coördinated. And, once properly placed, the models can be photographed to give the installation men clearer conceptions of what is wanted than can be had by reading blue prints.

With plant changes as frequent as they are today, the models also serve to show how rearrangements will look, and how new products can best be accommodated on present production lines.

In an Army tank a GUNNER fires with deadly accuracy – while charging across rough terrain – because of a gun stabilizer, officially recognized as one *outstanding advantage* of our tanks over those of the enemy.

. . . the name on the GUN STABILIZER is Westinghouse.



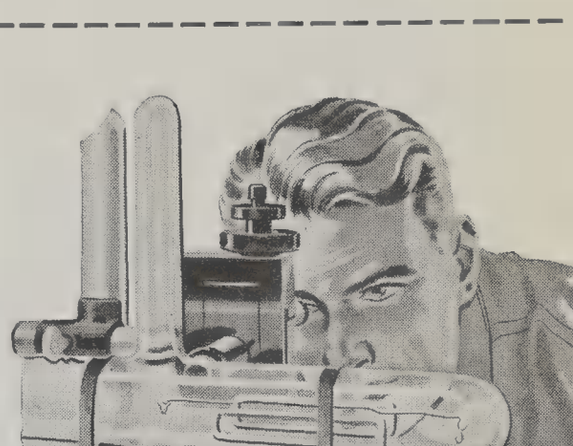


In a steel mill an ENGINEER uses an induction heater to fuse a mirror-like surface on dull electrolytic tin plate – helping to conserve *two-thirds* of our war-scarce tin supply.

. . . the name on the INDUCTION HEATER is Westinghouse.

In a laboratory a SCIENTIST uses a micro-balance to weigh a *single layer of oxygen atoms,* 1/50,000,000th ounce, to determine the corrosion resistance of special alloys at high temperatures.

. . . the name on the MICRO-BALANCE is Westinghouse.





In a bomber a BOMBARDIER "pin-points" his target with an American bombsight – controlled by a gyroscope which is driven by an electric motor, balanced to *1/10,000th ounce.*

. . . the name on the ELECTRIC MOTOR is Westinghouse.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY – Westinghouse is producing vital war equipment and weapons, many of which must remain secret until after final Victory.

TOMORROW – These wartime developments will be turned to peaceful uses – products for industry and the home, backed by Westinghouse research, engineering, and precision manufacture.

Tune in: JOHN CHARLES THOMAS–Sunday 2:30 pm, EWT, NBC • TED MALONE–Mon. thru Fri., 11:45 am, EWT, Blue Network

Better Plastics Heating

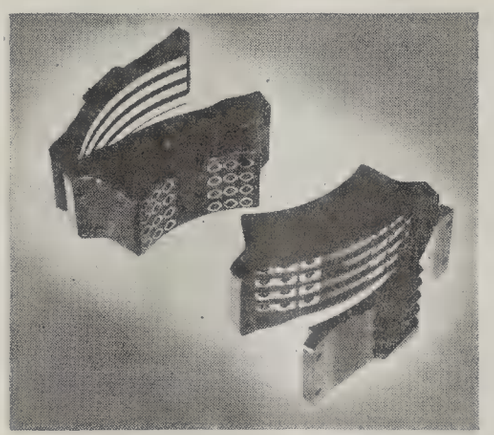
In Wood Fabrication and in Preparing Plastics Materials for Molding, High Frequency Heating is Well into the Development Stage. The Success that Has Been Attained Bids Fair to Influence Favorably The Rapid Production of Even Large and Complicated Plastics Parts

HIGH-FREQUENCY heating is now being used to an ever increasing extent as a means of preheating plastics molding materials and of accelerating curing of synthetic resins used as adhesives in wood fabrication. For this latter purpose, high-frequency power has proved to be remarkably useful. For example, it is responsible for the record of one company in turning out cargo-carrying glider parts at a continuously increasing rate with an ever decreasing cost to the Government. In this instance the electronic device was originally intended to facilitate gluing of laminated parts for grand pianos. However, when all piano manufacture ceased by order of the War Production Board in May 1942, only the fashioning of various new jigs and fixtures was necessary to convert the high-frequency unit to work on resin-bonded aircraft parts.

Experience in the wood fabricating field has indicated that the location and arrangement of the electrodes has a vital effect on the ability of the high-frequency machine to transmit the power through the system of electrodes and on the likelihood of the work absorbing this power uniformly and utilizing it as heat. The three established methods of introducing high-frequency heat to a glue line or to a mass of material are known as perpendicular, parallel, and stray field heating.

Perpendicular heating is referred to when the glue lines or planes are perpendicular to the electrostatic field and parallel to the electrodes. The gluing of veneers in the manufacture of plywood or the gluing of laminations to form curved sections such as wing bows are considered as being treated by perpendicular heating. The preheating of plastics materials before molding, to be considered in more detail later on, is also done by perpendicular heating.

Parallel heating requires that the plane of the glue line be parallel to the electrostatic field and perpendicular to the electrodes. This method is considerably more efficient than perpendicular heating since the power is absorbed almost entirely by the glue line rather than by the wood itself. For example, where wing spars are being made of several laminations that are a half-inch or more in thickness, the power required to set the glue in perpendicular heating would be beyond the range of the ordinary machine of 15 kilowatts or less. However, if the electrodes are located so that only the glue lines are treated—that is, by parallel heating—the power and time requirements are reduced enormously.



Use of a five-kilowatt high-frequency oscillator to preheat preforms not only increased production but lowered warpage in molding this phenolic part used in an electrical assembly for feathering propellers

Stray field heating offers the greatest possibilities but is the most complicated of the three methods. In this case advantage is taken of the fact that the electrostatic field set up by two adjacent conductors or electrodes, usually in the form of tubing or rod, does not travel on a straight line between these conductors. The field spreads out or widens as it leaves one electrode and finally converges as it reaches the other. Thus it is possible to reach glue lines and surfaces that are not directly in line with the electrodes but are a definite distance above or below them.

NOT A CURE-ALL—In the field of wood fabrication as well as in that of preheating molding materials, high frequency has certain shortcomings. It is not a cure-all. Where the section to be heated is very thin, a steam plate or electrical resistance grid usually is more desirable. High frequency should be used in objects where the physical dimensions do not allow for uniform distribution of ordinary heat. Conventional heating methods are definitely not satisfactory where the depth of heat penetration is more than ⅜ or ½ inch.

The most important use of the high-frequency machine in the wood-working industry is to speed production. And this it has done by drastically reducing the time required to cure a glue joint—cutting it from four to six hours to a matter of seconds or minutes.

Preheating of molding materials prior to the pressing operation is not new. Through such heating it has been possible to improve the flow of material to the mold, accelerate the closing of the mold and the curing of the piece, and reduce closing pressures. However, although many advantages have been obtained by this method, the fact remains that molding materials, being insulators, resist heat absorption. Because of this, a preform which is heated without benefit of high frequency is much hotter at the outside surface than it is at the core.



Courtesy Bakelite Corporation

At left is a molded block of woodflour-filled phenolic material which was cured in one hour at 320 degrees, Fahrenheit, at a pressure of 2100 pounds per square inch. Made of the same material and molded at the same heat and pressure, the block at the right, six inches by six inches by two inches, was cured heatronically in five minutes

In fact, the material may be relatively cool at its core when the outer surface has become crusted.

PREHEATING PROCESSES — One common means for preheating is the double steam plate in which a layer of preforms is placed between the upper and lower plate. Another method employs an oven with shelf arrangement. With this setup, either preforms on trays or bulk powder in pans can be heated. These methods have been used for years and, no doubt, always will be used. But in principle they are resisted by the materials themselves.

In contrast, the development of radio frequency for preheating has, for the first time, given the molding industry a method whereby a charge of material can be heated nearly uniform throughout its mass in a very small fraction of the time previously consumed. Of particular importance is the fact that when a preform is heated in this manner the heat is generated uniformly throughout the material, irrespective of size. And the rate at which this heat is developed is directly proportional to the power input. This means that the heat conductivity of molding materials, precluding size and weight as limiting factors, no longer has to be considered. Thus, theoretically, any quantity or weight of thermosetting molding material can be heated to molding temperature.

With minor modifications, the heatronic process is applicable to the molding of a variety of plastic materials. Thus, thermoplastics may be molded with considerable advantage by compression. Brake-lining materials have also been heated and molded satisfactorily from preforms and powder. If certain precautions are taken—especially as to rate of heating—materials which are partially conducting and materials containing conducting particles can be heated in this manner and molded. Colored and mottled materials as well as black and brown phenolic compounds will mold satisfactorily when heated by high frequency. Experience has indicated that, generally speaking, the slower curing materials are preferable for thick sections and for moldings requiring exceptional flow. Although urea and melamine are more critical in this respect than phenolics, they have been molded by the heatronic process with considerable success.

METHODS OF APPLICATION — There are a number of methods of adapting this heating technique to present-day molding. A simple yet effective system consists in heating the preformed material to molding temperature in the electrostatic field which is set up outside the molding press. After heating, the material is quickly transferred to the mold or transfer pot, and the press is closed rapidly so that the desired flow is obtained prior to hardening. This transfer of the preheated material may be manual or automatic.

Such an arrangement can be varied in a number of ways. In transfer molding, the electrostatic field may be created over the mold and the heated material allowed to drop into the mold or be forced in by the mold plungers. In the case of a horizontal ram in the transfer mold the electrostatic heating plates may be mounted between the ram and the mold.. Here use would be made of the ram to force the heated material into the mold.

The size of the high-frequency heating equipment depends upon the size of the job to be done. In the past year new designs have been engineered to meet efficiently the specific needs of the plastics industry, extreme simplicity and ease of operation being the keynotes. Keeping in mind the fact that preforms differ markedly in size and shape, provision has been made in some of these units for changes in the size of the electrodes. And safety devices have been featured throughout.

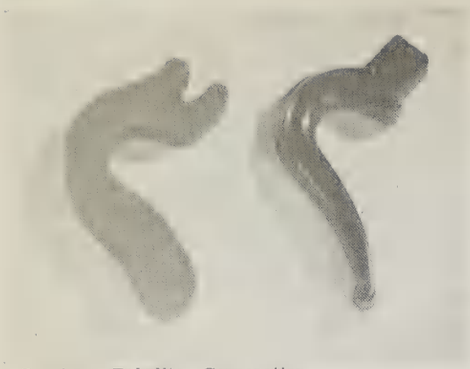
The advantages of preheating are numerous. Briefly they may be summarized as follows: precise control of preheating; shortening of the preheating time; much lower molding pressures; less mold distortion and damage; simpler molding cycles; fewer contraptions at the press; simplified material loading; less material handling; slightly less loading weight; lower plasticity required; less warpage experienced; no "weld" lines; minimized internal stress in the molded piece; uniform density of the part; thoroughly cured molded piece; generally improved properties; more pieces per press and per man-hour; much faster cure.

"IMPOSSIBLE" JOBS—Just what these advantages mean is perhaps best explained by citing a few of the seemingly impossible jobs that were successfully molded through the use of high-frequency



Courtesy Joseph Stokes Rubber Company

To obtain maximum results from a high-frequency oscillator, one company has engineered a conveyor system for the speedy transfer of preheated forms to the presses



Courtesy Bakelite Corporation

Made of phenolic material, the preform at left was electronically heated to 300 degrees, Fahrenheit, in 30 seconds and molded in 45 seconds at 320 degrees to form the handle for a coffee maker pictured on the right

heat. There is, for example, the phenolic head of a chemical pot-feed device in a water purifying unit. In producing this head part—a fairly large part weighing approximately 1 pound 6¾ ounces and measuring about 5 by 5 by 2 inches—the molder wanted to make sure that there would be no leakage between canals molded in the head and that no cracking would take place in the part under extreme temperature changes. Before the molder adopted high-frequency heating, at no time was he able to produce a head that did not have porous internal sections which resulted in leakage between the canals. However, the uniform preheating of the material by high-frequency produced complete uniformity of the molded part with no indication of any porosity or internal strains.

An even more difficult molding problem satisfactorily solved through the use of high-frequency heating was an aircraft engine ignition distributor head molded from asbestos-filled melamine compound. The difficulty lay in a combination of circumstances: The low thermal conductivity of the compound, the size of the part, the close nesting of a large number of pins, and the complex arrangement of 17 inserts. To secure proper flow from the transfer chamber into every section of the mold, the 2¼-pound preformed plastics was preheated to 250 degrees, Fahrenheit, before it was placed in the loading well. Only by a rapid, uniform heat could such a mass be heated to the center without overheating the surface at the same time. If the core were underheated, the material could not be made to flow into the cavity without the use of such great pressures that pins would be broken or bent and inserts sheared off or moved out of position. If the surface of the preforms were overheated in an attempt to soften the core, the compound would begin to set—with equally disastrous results. Before the installation of high-frequency equipment, the rejects often ran as high as 30 to 50 percent of the day's output. However, once high-frequency was adopted for the heating of the preforms, this percentage dropped below 5 percent.

High-frequency heating as applied to the plastics industry is well into the development stage; the work that has thus far been accomplished with its help in this field is indicative of how research and development can influence and change the course of business.

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VENTILATING DUCTS

Made of Steel Springs and Plastics Treated Fabric

FRESH clean air is assured construction men working in such enclosed spaces as the holds of ships by portable "Ventube" flexible ventilating ducts developed by E. I. du Pont de Nemours and Company, Inc. Designed for either blower or exhaust systems, the unit consists of a tempered steel helical spring inside a tube of specially selected fabric which has been impregnated and coated with a high-grade abrasion-resistant plastics compound that is water-resistant and impermeable to air. When bent to an angle of 180 degrees, the new Ventube will exhaust more air than the old-style tubing, and, in addition, it weighs only half as much as an equivalent length and diameter of the earlier types.

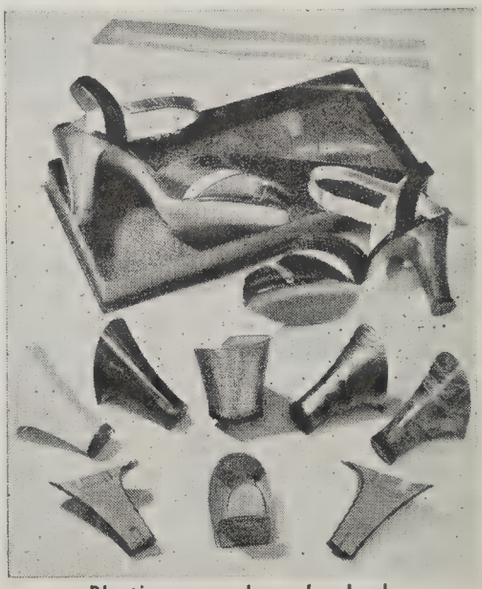
BETTER HEELS

Result from Improved Plastics Injection Method

AS A RESULT of a new development in injection molding, the wooden heel cores of women's shoes can now automatically be given an evenly distributed coating of cellulose acetate approximately 1/16 inch thick. The new plastics-covered heels, which are said to have wearing qualities far exceeding those of any other shoe, will not scratch or scuff, nor will the coating wear off, split, or peel. The latter characteristic can be attributed to the fact that the plastics is slightly impregnated into the wood under the pressure of injection. There is no seam, and the process, which was developed by Pereles Brothers, can be used for any size, shape, or style.

According to the results of repeated tests, the coating is not affected by temperature changes or by the action of any elements. The heels can be made in either dull or glossy finish in practically every color.

In previous attempts to mold a plastics shell or coating around a shaped wooden core, difficulties were encountered, due mainly to the high pressure employed in the injection process. With the wooden forms supported in the mold by



Plastics covered wooden heels

pins extending into opposed ends of the core, the pressure of the molten plastics material entering the mold by the usual direct feeding methods shifts the core on the supporting pins. This movement often results in unequal application of the coating material to the core.

To overcome this difficulty, a new type of gating was adopted. It is essentially a modification of a ring gate. The spaced indirect feeding arrangement made possible by this gating provides for simultaneous and uniform flow of the cellulose acetate, under similar pressure conditions, all about the core. Consequently, there is no tendency of the core to be shifted, and the coating is uniform throughout.

COLORED CONNECTORS

Insure Safety in Electrical Installations

FOR EASE of installation and to simplify replacement work and trouble-shooting, H. B. Sherman Manufacturing Company has adopted red plastics fixture connectors for use on current-carrying wires and white plastics connectors for grounded wires. This color code also lessens the danger of accidents. Detroit Macoid Company molds the fixtures from Vinylite because of its non-flammability, high tensile strength, moisture resistance, and electrical resistivity.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

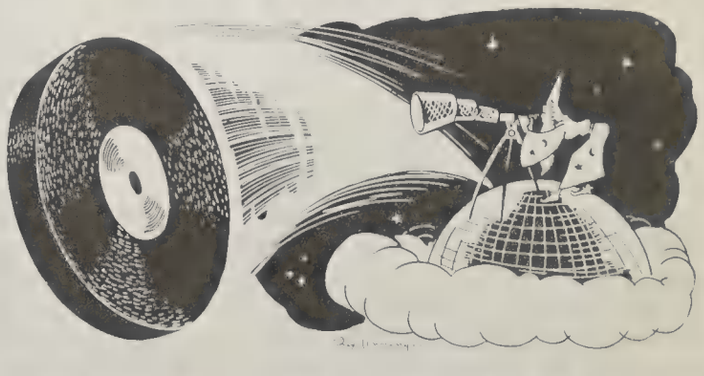
MOLDING COMPOUNDS



THRIVING ON A DIET OF "LIGHTNING BOLTS"

The rigid requirements for arc resistance, dielectric strength, and heat resistance which the modern distributor cap must pass call for a plastic compound of unusual versatility. Naturally, this means that the automotive distributor cap manufacturer looks to the phenolics because these are the most versatile of all plastics . . . and when he looks to the phenolics he looks to Durez — specialists in this field for the past quarter century. In addition to the electrical and heat resistant properties which a plastic compound for a distributor cap must have, the Durez phenolic molding compound selected for this job possesses such characteristics as good moldability, moisture resistance, and low shrinkage. You will find the versatility of the more than 300 Durez phenolic molding compounds is the natural starting point for selecting a plastic material that fits your job.

INDUSTRIAL RESINS



LOOKS LIKE A LONG HARD GRIND AHEAD

Grinding wheels bonded with Durez resin possess the durability, strength, and accurate grinding power so necessary for efficient production. Relatively simple to produce, Durez-resin-bonded grinding wheels are typical of the many—almost limitless—applications which Durez bonding resins have made available to the progressive manufacturer with an eye on post-victory markets.

OIL SOLUBLE RESINS



THE NEXT BEST THING TO THE FOUNTAIN OF YOUTH

Durez resins impart to aluminum paints the brilliance, gloss, and durability that make them amazing life prolongers for such items as petroleum storage tanks. A myriad of wartime developed (and proved) applications for Durez resins in the protective coatings field opens new horizons for the alert manufacturer.

● Versatility is a much misused word and, especially when referring to the properties of plastics, deserves elaboration. When we say that Durez phenolic resins and molding compounds are versatile, we mean that they possess a wide range of highly desirable properties such as highest dimensional stability under all types of climatic conditions, chemical resistance, impact strength, heat resistance, diversity of finishes, dielectric strength, and moisture resistance. But there is even more to it than this—for when you add to the product versatility of Durez plastics the many new molding methods and processes developed by your custom molder and the tremendous advances made with Durez resins in the impregnating, bonding, and coating field, you can readily understand the tremendous scope that is now available to the imaginative design engineer. The benefits which the wide experience of Durez technicians and the wealth of data available in our files can offer are available at all times towards the successful solution of any plastic material problem which you may have. Durez Plastics & Chemicals, Inc., 527 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

Control In The Air

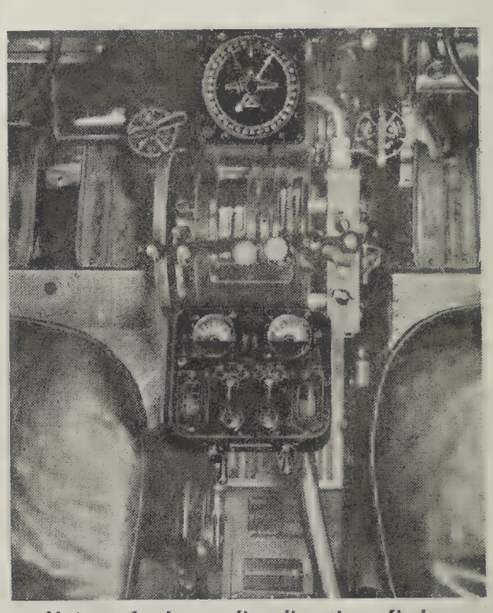
Electronics Has Brought to Aviation a Versatile Means of Controlling Many of the Airplane's Essential Mechanical Components. Increased Engine Efficiency, Reduced Pilot Fatigue, and Greater Safety are Some of the Worthwhile Results that Have so Far Been Obtained

THE SCIENCE of electronics is highly complex, yet the principles underlying most aircraft electronic installations are relatively simple. The heart of every installation is the amplifier circuit which, with electronic tubes, boosts a very small amount of electric power to usable proportions.

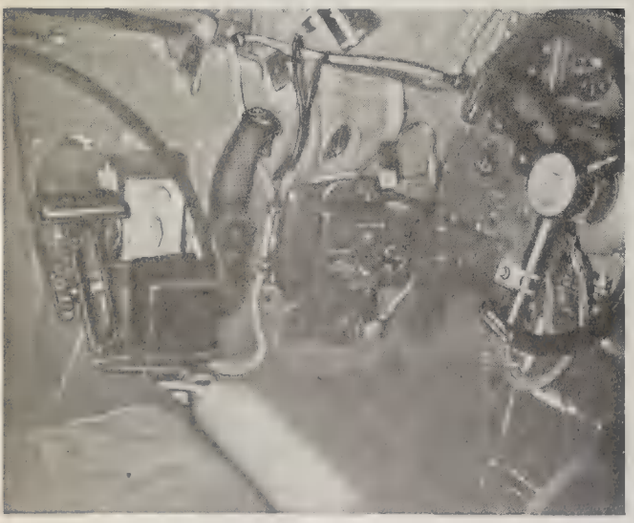
Of the many methods of creating the initial impulses in an electronic control system, it will be sufficient to say that they can be created by moving a coil in a magnetic field, or by changing the intensity of a magnetic field near a coil; by changing the capacity of a condenser; by varying resistance in one branch of an electric circuit; by photoelectric action; by employing the varying electrical resistance of materials at different temperatures; by actually breaking or closing an electric circuit; and so on.

REGULATING SUPERCHARGERS — One of the most important adjuncts to the military and commercial airplane is the turbo supercharger, indispensable to flight at great altitudes because it raises the rarified air to a pressure at the carburetor inlet almost equal to that at sea level. When the pilot has to control the action of the supercharger, he adds greatly to his already complex duties; hence such an automatic electronic control as developed by the Minneapolis-Honeywell Regulator Company is a valuable addition to aircraft instrumentation.

In a typical airplane engine equipped with a turbo supercharger, hot exhaust gases from the engine pass through the inlet and enter the nozzle box which surrounds the turbine wheel. Since it is the turbine wheel which drives the supercharger, and since it is the speed of the supercharger which largely regulates the pressure boost at the carburetor, the problem is to control the speed of the turbine wheel automatically. Basically, speed control is dependent on the waste gas. With the waste gate closed, all the gases impinge on the turbine and its speed is then at a maximum. As the waste gate is opened, more gases escape to the atmosphere, and the speed of the turbine decreases. Air is brought into the supercharger or turbo compressor inlet, and its pressure is increased by the impeller. Compressed air when heated lessens volumetric efficiency at the engine. To avoid this, the heated air is first led to an intercooler, where it is cooled by air brought in from a scoop, and then is passed on to the carburetor. An internal blower still further increases the air pressure before it passes to the engine manifolds.



Units of the radio direction finder as seen from a position just behind the seats of the pilot and co-pilot



The electronic control stick, which makes close formation flying easier for the pilot by reducing fatigue, has a comfortable pistol grip and adjustable arm rest at left

ELECTRONICS DOES IT—Control requirements of the supercharger are many and severe. It should be completely automatic. Fluctuations in engine power must be met quickly and accurately; control of power must be by boost pressure rather than by throttle. For safety's sake, the turbine must not exceed a certain speed, or manifold pressure a certain value; low temperature must not be a bar to efficient operation. The combined efforts of the mechanical engineer and the electronic specialist have met these requirements completely.

The sensitive unit of the supercharger control system is the Pressuretrol which measures electrically the pressure of air supplied to the carburetor. It consists of two operating bellows and a reference bellows. Together they move a potentiometer contact by means of a sector arm and a pinion gear. Then

there is a waste gate motor which is a two-phase reversible electric motor operating a balancing potentiometer within its own case. Another unit is the turbo governor, driven by a flexible shaft from the supercharger. One part of the turbo governor prevents overspeeding; the other part anticipates overshooting of the manifold pressure.

All these units are connected in the main junction box to a complex electric bridge circuit. When the units produce conflicting electric effects on the bridge circuit, an unbalance is signalled, amplified by the electronic amplifier, and the waste gate motor is set into operation.

In a plane equipped with an automatic supercharger regulator, the pilot selects engine speed by setting the propeller governor control on his dashboard, and opens the throttle wide. The internal blower gives a constant boost, so that if the turbo boost selector gives a constant pressure before the carburetor, a constant manifold pressure is bound to follow. Once set, the delicate electronic system keeps pressure constant and prevents overspeeding of the turbine. Because of electronic amplification, all signalling and "thinking" devices can be small and delicate, yet their final action powerful and rapid.

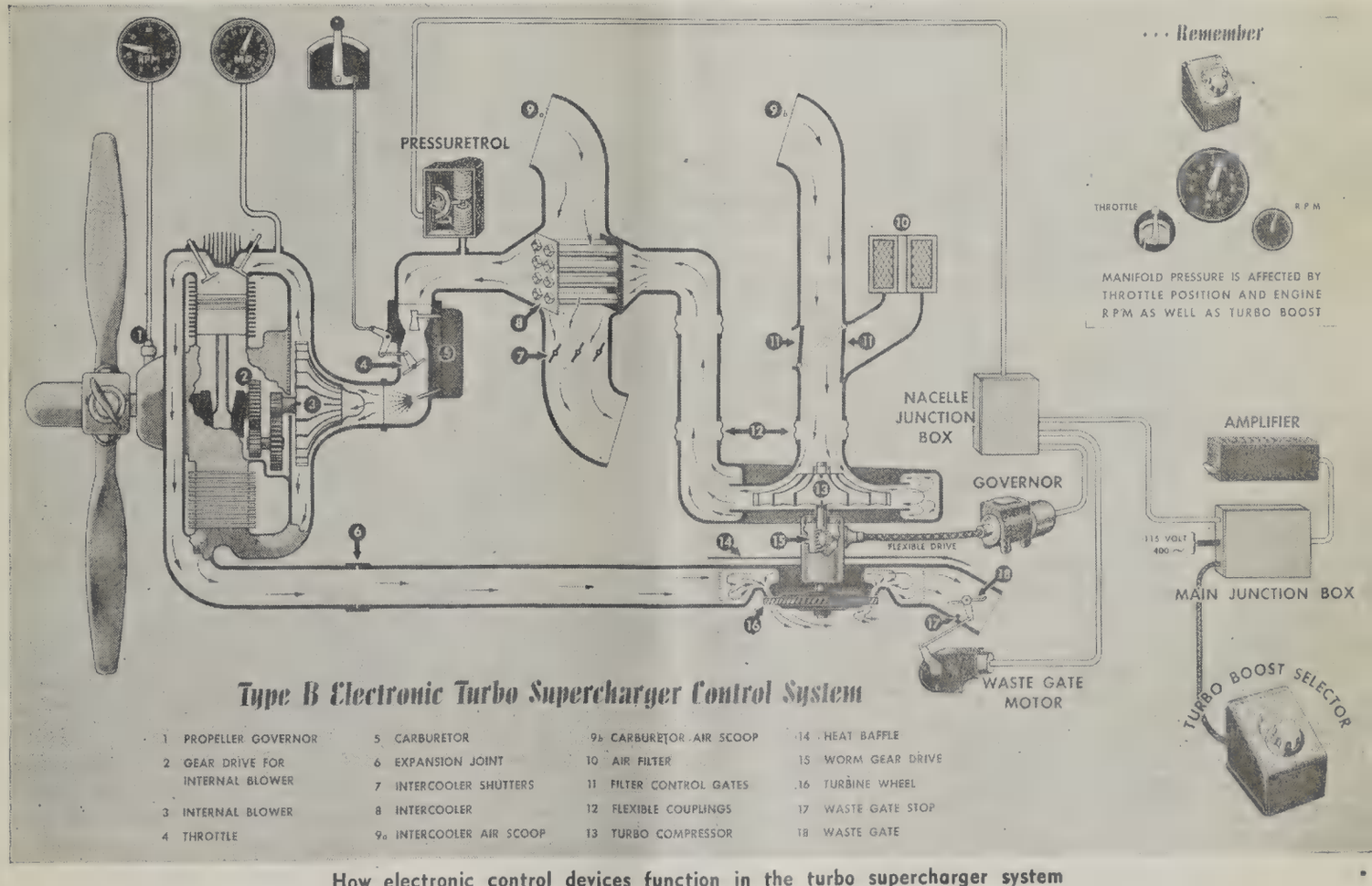
CABIN COMFORT—Control of the temperature of an airplane cabin is another extremely important phase of aerial flight which is being taken over by electronics. Post-war, equable cabin temperature will be maintained on our airliners, even though the airplane moves from one temperature to another in a matter of seconds, and sometimes these changes are as much as 50 degrees or more. The new Minneapolis-Honeywell "electronic cabin temperature control" is a package unit weighing slightly under eight pounds. It maintains the desired cabin temperature of 70 degrees, Fahrenheit, automatically in spite of extreme fluctuations outside.

The temperature control system includes an outside air compensator. This is a small coil of wire installed in the duct bringing the air into the cabin heaters. Temperature fluctuations change the electrical resistance of the wire. The change in resistance is slight, but even the smallest variation is amplified through electron tubes. Serving as the brains of the system, the tubes learn from the compensator coil whether the outside air is colder or warmer, and send electrical messages to a motor which opens or closes a mixing damper, proportioning the amounts of outside air mixed with heated air from the plane's cabin heating system.

THE AUTOPILOT—Electronic devices do not constitute a whole control system, but merely act the "liaison" part. This is well exemplified in the "electronic autopilot." The primary unit is not electronic nor even electrical in character. It is a gyroscope or a number of gyroscopes in a case fixed to the plane. The plane may dive, climb, or bank, but the gyro rotor remains fixed in space. In older systems, the difference in attitude between rotor and its case-operated ports or valves led compressed air or hydraulic pressure through piping to servo motors. The servo motors in turn operated the rudder, ailerons, or elevator.

In the electronic autopilot, the relative displacements of gyro and plane are picked up electronically and amplified into a force strong enough to actuate the control surface motors. It is claimed for the electronic autopilot that its action is practically instantaneous and refined; that the connecting electric wires are immune to extreme cold; and that no leakage of air or hydraulic fluid is to be feared. Another advantage is that the control surfaces are connected by many fine wires, making it more difficult for gunfire and flak to put the autopilot out of commission as compared with mechanical, pneumatic, or hydraulic systems. It is no longer a secret that the electronic autopilot is used on bombing aircraft such as the B-17's, B-24's, and B-29's to relieve pilot fatigue on long runs. It also enables the airplane to be flown from two or more stations. Pilot or navigator may be disabled, but another member of the crew can carry on.

It is now permissible to say that



How electronic control devices function in the turbo supercharger system

the electronic pilot has proved most useful in precision bombing. With the automatic correction it introduces, it is the bombardier who actually operates the plane on a bombing run. The result has been to reduce the vulnerability of our aircraft because the effectiveness of enemy anti-aircraft fire is directly related to the time consumed in the bombing run. Single aircraft have made approaches with runs of only eight seconds. The greatest contribution, of course, is improved accuracy of bombing.

ELECTRONIC JOY STICK—The "formation stick" is an original war-time electronic development. In early flights of American heavy bombers over enemy territory, attacks by enemy fighters compelled the use of tight formations, with planes flying almost wing-tip to wing-tip. In turbulent air, such precision flying called for great effort on the part of the pilots who often arrived over their target fatigued, just when precision bombing demanded their utmost alertness. Accordingly, Wright Field encouraged the development of a device which would take over all effort required in formation flying and substitute the servo motors of the autopilot for the muscles of the flyers.

As seen in the pilot's compartment of a bomber, the formation stick is a pistol-gripped lever about ten inches long, free to move in all directions in exactly the same manner as the joy stick of pursuit aircraft. Through amplification of the electric variations introduced by the motion of the stick, and with the aid of the servo motors of the control surfaces, the stick moves the airplane in the same direction as, and proportionately to, its displacement. A stabilizing mechanism has been added to give the stick "feel" and prevent the application of too abrupt control.

DETECTING DETONATION—Detonation in an internal-combustion engine is the compression-ignition of the last part of the cylinder charge to burn, with high localized pressures and temperatures. Both of these may be damaging to pistons and cylinders. Early experiments in detonation detection involved actual measurement of the pressure in the combustion chamber and an analysis of the exhaust gases. Later investigation has shown that detonation can be detected by observing changes in the frequency of the vibrations transmitted through the cylinder wall.

In the "detonation indicators," developed by the Sperry Gyroscope Company, a pick-up unit is attached to the cylinder wall and connected through an amplifier to a neon light indicator on the instrument board which flashes a warning when detonation conditions occur. No piercing of the cylinder is necessary to make an installation, and the equipment will serve all types of power-plant installation. Further, it is possible to discover immediately which cylinder is at fault by the operation of a selector switch.

DE-ICING—Among the many electronic devices developed by the Eclipse-Pioneer Division of the Bendix Aviation Company is one that improves the efficiency of the de-icing boots used on the wing edges of airplanes. The new control permits a more selective method of inflating and deflating the tubes along the wing edges so that ice broken loose by the pulsating rubber can be carried off by the slipstream.

Pressure and suction manifolds are located at the individual de-icer boot connections. The manifolds are operated by solenoid-actuated distribution valves, precisely and instantly controlled by an electronic timer. Originally there was a single recurring cycle of inflation and deflation fixed at approximately 40 seconds. Now an electronic device measures the thickness of the ice and permits the pilot to vary the frequency of the pulsations in relation to the thickness and type of ice being formed.

OTHER APPLICATIONS—Electronic flame detectors, in which photoelectric cell circuits are affected by the presence of flame or smoke, serve as quick-acting fire alarms. An engine temperature control furnishes voltage to the amplifier, so that temperature variations operate cowl flaps, admitting more or less cooling air as circumstances warrant. Remote actuation of airplane controls and accessories by electronic means has been greatly aided by the design of small but powerful electric motors of low inertia and with the ability to turn rapidly in either direction. The Sperry automatic direction finder makes every radio transmitter a possible source of guidance. The list of such appliances could be extended almost indefinitely, but enough has been recorded here to show that electronics has already served the airplane to an extraordinary degree in control, in all manner of instruments and engine auxiliaries, and in navigation. There is not the slightest doubt, moreover, that electronics will be one of the most important contributing factors in the growth of safety and comfort in post-war flight.

AIRCRAFT PILLOWS

Quickly and Easily Turned Into Jacks

AN INTERESTING new device, developed by the Air Technical Service Command at Wright Field, is simply a giant pillow used to jack aircraft on soft ground or after they have made crash landings. It appears that the idea originally came from our German enemies. The British learned it when they captured some pictures of giant rubber bags being used as airplane jacks. They quickly passed it on to the AAF, and the Air Technical Service Command's equipment laboratory added improvements. One of these is a device for lacing the bags together so that high-wing planes could be lifted to almost any desired height.

The photograph shows and explains the equipment. It weighs 220 pounds and can be carried in almost any airplane. It comprises a set of three bags and one gasoline-engine-driven blower or compressor. Each bag is six feet high and only two are required to lift most airplanes, although a B-24 Liberator takes four

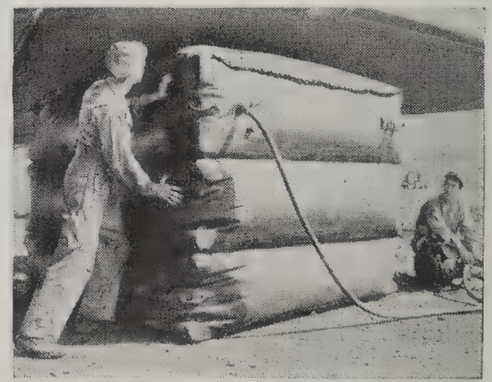


Photo by Air Technical Service Command
Air pillows lift a plane

bags and a B-29 Superfortress takes eight. Each bag can support 12 tons, measures approximately six and a half feet square, and is filled with air at a pressure of three pounds per square inch.

Experience shows that it is far simpler to slip deflated bags under the wings of a belly-landed plane and inflate them than to use the old method of excavating and inserting hydraulic jacks. Even a motorist might at times like to have something of the kind instead of painfully manipulating a conventional automobile jack.

Gas In Bottles

Liquefied Petroleum Gas, Because of its High Thermal Efficiency and Adaptability to Convenient Storage and Transportation, has Come to be an Important Factor in American Economy, Both Domestic and Industrial. Its Uses are Widely Varied and They are Increasing Rapidly

By BUDD MULLOY

ONE of the growing industries in the United States is the production, distribution, and marketing of liquefied petroleum gases—butane and propane. Before LP-Gas became one of the vital materials of war, the annual consumption for domestic, commercial, industrial, and chemical purposes was increasing at an average rate of almost 50 percent a year. While consumption for normal purposes has remained almost static during the war, consumption for war purposes has skyrocketed. New facilities established since 1940 multiply by many times the previous production possibilities.

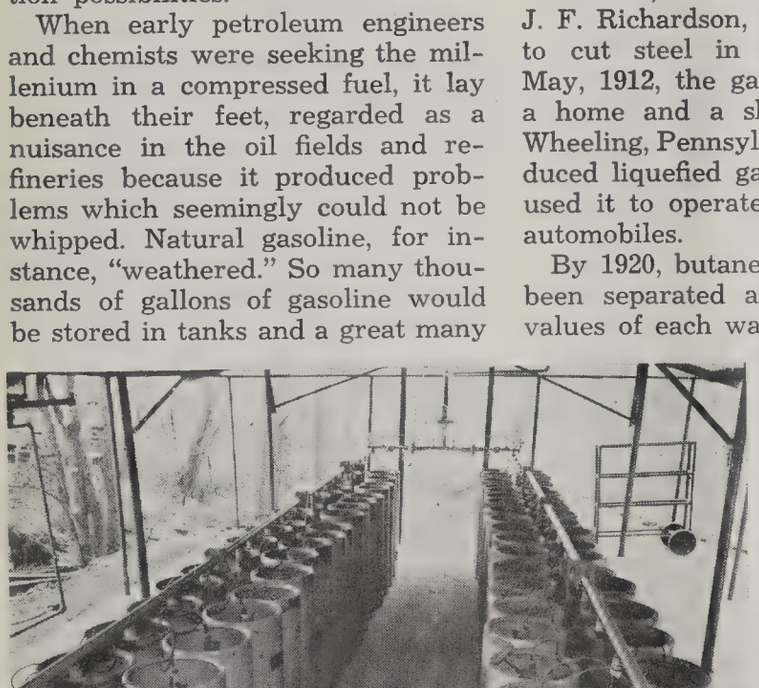
When early petroleum engineers and chemists were seeking the millenium in a compressed fuel, it lay beneath their feet, regarded as a nuisance in the oil fields and refineries because it produced problems which seemingly could not be whipped. Natural gasoline, for instance, "weathered." So many thousands of gallons of gasoline would be stored in tanks and a great many less gallons could actually be sold. The balance escaped as a gas.

After the turn of the century, the Riverside Oil Company owned nine natural gasoline plants and the general superintendent of the company, A. N. Kerr, determined to stabilize his gasoline and abate the nuisance. He and Herman Stukeman, a young company engineer, worked long and hard on the problem. Finally they decided to condense the escaping gases and in 1910 produced about 200 gallons of the condensate. It proved to be a mixture of butane, propane, and other hydrocarbons.

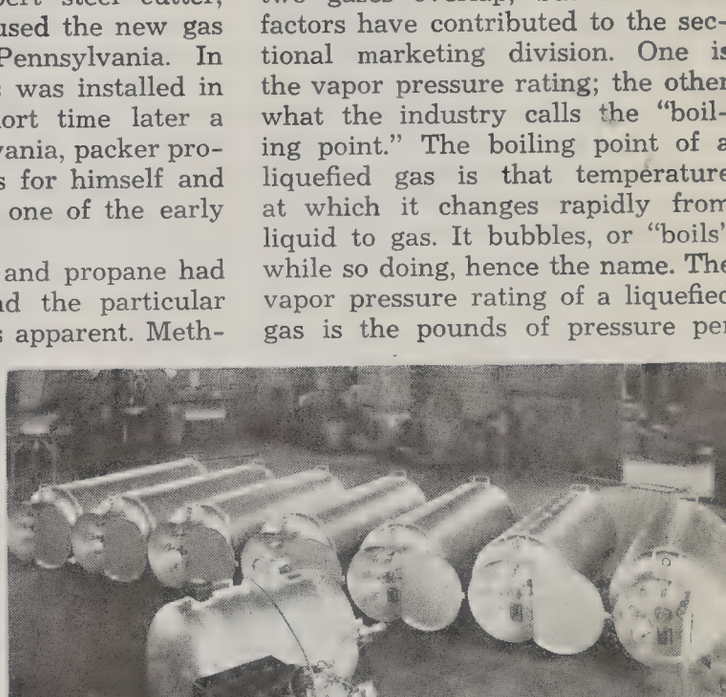
In 1911, an expert steel cutter, J. F. Richardson, used the new gas to cut steel in Pennsylvania. In May, 1912, the gas was installed in a home and a short time later a Wheeling, Pennsylvania, packer produced liquefied gas for himself and used it to operate one of the early automobiles.

By 1920, butane and propane had been separated and the particular values of each was apparent. Methods of transportation, control, and "packaging" were being tried out. Procedures of selling were getting their first tests. New capital, large and small, entered the business. During the 20's big oil companies created subsidiary companies and chemical companies did the same. All were seeking to capitalize on the growing potentials of LP-Gas as a fuel.

GAS IN LIQUID FORM—The molecular formula for propane is C_3H_8. The designation for both normal butane and isobutane is C_4H_{10}. While both of these arrangements of carbon and hydrogen atoms do much the same industrial and domestic jobs in much the same way, they differ in qualities and advantages. These differences explain the geographic line in their marketing. Of course, markets and uses for the two gases overlap, but two basic factors have contributed to the sectional marketing division. One is the vapor pressure rating; the other what the industry calls the "boiling point." The boiling point of a liquefied gas is that temperature at which it changes rapidly from liquid to gas. It bubbles, or "boils" while so doing, hence the name. The vapor pressure rating of a liquefied gas is the pounds of pressure per



At a war plant, batteries of 100-pound tanks of LP-Gas are manifolded to supply ample gas at required pressure



The manufacture of LP-Gas tanks and systems is an important part of the business of many metal fabricating plants

square inch at a certain temperature.

The great advantage of propane is that the boiling point, where it vaporizes rapidly, is about 44 degrees below zero, Fahrenheit. The disadvantage lies in the fact that its vapor pressure at 70 degrees above zero is 109.3 pounds per square inch. The containers in which it is merchandised weigh, roughly, about as much as the gas in them. Thus 100 pounds of gas sold means 300 pounds of total transportation—the cylinder weighing 100 pounds making a round trip journey in order to sell 100 pounds of gas to the customer.

When butane is used in the north it must be protected from the cold, and a system of artificial heating is required, since the boiling point of normal butane is 31.8 degrees *above* zero, Fahrenheit. It readily vaporizes above about 35 degrees and has little, if any, pressure below that level. On the other hand, the pressure per square inch of liquefied normal butane is only 16.9 pounds at 70 degrees. In general terms, this means that butane can be stored and transported in less expensive, lighter equipment than is required for propane.

Most of the LP-Gas sold is not pure propane or pure butane. This lack of "purity" does not mean a lack of virtue or that the product is dirty or undesirable. It means only that it has not been necessary to carry the separation process to the final degree, and that there is butane in the propane and vice-versa. As a matter of fact, many distributors deliberately mix the two gases, to arrive at a blend suited to the area and the climate in which the mixture is sold and the purpose for which it is intended. Butane gas for smudge pots, for instance, is often "needled" with propane to lower the boiling point to the desired figure.

IN THE HOME—More than 2,000,000 American homes today are equipped for cooking, water heating, refrigeration, or room heating with liquefied petroleum gas fuel. These homes are in the suburbs of the cities, in the fringe areas of the large cities themselves, in small cities and towns, and on farms.

The importance of this 2,000,000 home figure is realized by looking at other figures. More than 18,000,000 families in the United States cook with gas of all kinds—natural, manufactured, and liquefied petroleum gas. This means that about one in every nine gas ranges in the country uses LP-Gas.

The gas range used with LP-Gas is much the same as the range used in the city with manufactured or natural gas, but special designing has been done to make the most economical use of the richer fuel. Propane, as it flows to the range, has a BTU rating of 2526 per cubic foot. Butane has 3276 BTU to the cubic foot. The manufactured or natural gas flowing through city gas mains varies in richness, but most of it is about 560 BTU (manufactured gas) and seldom is it richer than 1100 BTU (mostly natural gas).



LP-Gas for this big plant is stored in the large tank in the foreground

Since proper combustion demands that oxygen be supplied in volume somewhat proportional to the richness or heating value of a gas, it is apparent that LP-Gas must have a larger intake of air than city gas. For this reason range manufacturers have designed special burners for ranges sold through LP-Gas dealers. The standard type range can be converted for use with LP-Gas, but those of special design are deemed more efficient.

A family of five persons will use, for cooking purposes, about 8.2 pounds of gas a week if their living scale is in the average bracket, but the amount may double that if the living scale is higher and the family entertains a great deal. A farm family using LP-Gas for cooking and for heating water will use about 14 pounds a week, according to tests. In a Southern home where large quantities of butane are used for room heating and the rate is consequently low, the cost of the fuel used for cooking may be as low as 10 cents a gallon, which is equal to about 2 cents a pound. The other extreme is the summer home in a resort area where only small amounts of gas are used and then only seasonally The price here may be as much as five times higher than the low price level.

In 1928, city gas companies distributing natural or manufactured gas purchased about 1,500,000 gallons of liquefied petroleum gas. This gas was used partially as standby supplies to insure delivery during emergencies and at times of peak load and partially to enrich other gas to keep it up to the set standards of the companies.

Since that year the use of LP-Gas by city gas companies has grown in leaps and bounds. In only two years since 1928 has the record shown a decrease. The other years showed substantial increases, from 10 to 66 percent each year. The 1,500,000 gallons sold in 1928 have grown to 46,000,000 in 1944. Many large cities now have LP-Gas in storage for emergency use and many more are using it to supplement their own gas sales.

LP-Gas is widely used for room heating, particularly in those climates where the weather is not severe but the temperature goes down rapidly after sundown. In these places the job assigned to space heaters is one of taking the chill from rooms. What is needed is a quick, instant heat. Many central heating systems are also operated on LP-Gas.

Room heaters are made in many forms. Among them are the radiant flame type heater, the floor furnace, and hot water or steam radiators with individual gas flame heating units. Some heater models are designed to fit in fire places or wall recesses; some are manually controlled and others automatically operated with thermostats. In size, their input ratings range from 7000 to 60,000 BTU per hour.

While individual room or space heaters are generally designed to be used as auxiliary sources of heat to a central heating system, they are satisfactorily employed for heating entire houses by multiple installation. Butane-propane mixtures are the gases most widely used. For this purpose, a large tank containing from 100 to 1000 gallons of gas is kept outside the house. Piping is run from this tank to each room in the house in which heaters or other appliances are installed.

LP-Gas is used on farms and ranches as a production tool. Wherever heat or flame is required

to boost farm production, or to cut manpower hours, the gas can do a useful job. The tasks assigned to it range from automatic smudge pots for the orchards and flame-throwing weed killers to such prosaic assignments as sterilizing milking equipment and heating chicken hatcheries. In between are the farm-factory jobs such as smoking meat, dehydrating fruits and vegetables, ripening fruits, and fueling the internal combustion engines in tractors and irrigation pumps.

GAS ENGINES—LP-Gas can be used as fuel for internal combustion engines. Some of the early streamlined trains were operated on butane. Railroads use it for compressors, cooking, refrigeration, and to run switch engines. Thousands of irrigation pumps throughout the west use the same fuel and some companies installed butane equipment on the heavy trucks in their fleet as much as 10 to 15 years ago. The buses of the Los Angeles Company were fueled with butane as early as 1930.

Prime advantage of butane and propane as a motor fuel is the fact that they go into the cylinder as a gas and remain so until fired. This means that there is no dilution in the crank case, that the lubricating oil is never stripped off the cylinder walls by the fuel, and that engines may run as much as ten times the normal mileage between overhauls.

A typical case is that of the Spokane United Railways, which converted all its buses to a butane-propane mixture in 1937. Exclusive of unloading and storage facilities, the cost of the change-over was about $250 for each vehicle. The fuel used was a mixture of 65 percent butane and 35 percent propane for summer use and a 50-50 mixture for winter. The temperature in Spokane ranges from —20 degrees, Fahrenheit, in winter to 105 degrees in summer.

Road performance of the Spokane buses has been materially improved over the experience with the same buses fueled with gasoline. Troubles due to vapor-lock were eliminated. Shop maintenance costs were reduced 30 percent. Much of this was because engine overhauls now are made about every 90,0000 to 95,000 miles instead of every 40,000 to 45,000 miles. In addition, it has been found that customers' complaints about obnoxious exhaust odors have been eliminated.

WIDE INDUSTRIAL USE—The abnormal demands for gas in a large midwestern city with many war plants during the past five years has created a fluctuation of gas pressure which upset many of the processes of manufacture. The solution was propane and butane installations at many factories. Constant maintenance of LP-Gas pressure, the assurance of clean, carbonless flames, and the accuracy of control has made a large contribution to the war effort in these factories and foundries. Most of these manufacturers have stated that even when conditions return to normal after the war the LP-Gas installations will stay.

Thousands of manufacturing operations are carried on with LP-Gas. Some of these installations are many years old; others have been born of war necessity. Torpedo hulls made in a Navy-operated factory in Indiana are heat-treated in an oil furnace. Since a draft of cold air coming through the opened door could make them imperfect, a curtain of flame provided by an LP-Gas installation protects the door. Whenever it is opened, tongues of flame shoot from top and bottom to meet and seal the opening against the cold. This is but one of many gas jobs created by the war.

In shipyards of both coasts and throughout the midwest much of the metal cutting is done with propane. LP-Gas, say the shipbuilders, saves time, money, labor, and material. It is reported that the kerf, or cut edge of a plate of metal so cut does not resist a grinder as does a kerf from an acetylene torch. This makes later finishing operations easier. The purchasing agent likes the fact that less gas is bought and the yard superintendent likes the fact that the men do not have to stop their work so often to change tanks. Layout men can figure on less metal loss between patterns and can often get an additional and needed piece out of a sheet.

Enamel baking, metal hardening, carburizing and cleaning, smelting and annealing—these are but a few of the additional jobs being done by LP-Gas.

GASES FOR CHEMISTS—The rearrangement of atoms in the molecule and the addition or subtraction of atoms to gain a desired effect is often referred to as "chicken wire chemistry." This reference comes from the molecular diagrams which the chemist draws on his research note pad as his work progresses. Through "chicken wire chemistry" the petroleum chemists and engineers have brought us synthetic rubber, 100-octane aviation gasoline, pigments. They can, and do, take to their work benches butane and propane, the common varieties usually known as "tank" or "bottled" ga and bring back carbon black, chlo roform, pure ethyl alcohol, indig formaldehyde, ammonia, and a larg number of additional substances.

High test aviation gasoline, upo which our fighting pilots depend fo their superiority in the air, repre sents another large chemical use LP-Gas. Large quantities of butan and isobutane have gone into th gasoline program. This use migh well be considered, too, a stabiliz ing influence for the industry. Ou post-war gasoline will have a muc higher volatility and octane ratin if a surplus of butane exists. Rathe than sell butane stocks at distres prices the refiner will either leav much of the butane in the gasolin or will add it if the gasoline doe not already contain enough.

The future of the LP-Gas indus try would seem to be one of con tinued expansion. New markets an new uses are constantly coming t attention; new methods of recover and distribution are in the offing and new higher stands of livin plus new industrial processes, wi push up and up the figures on th consumption charts.

SCIENTIFIC SEARCHING

For New Oil Sources Required by War Depletions

INTENSIVE post-war "prospecting by geologists using unusual scien tific methods in exploration for ne sources of oil and minerals was pre dicted recently by Professor Paul Kerr, head of the geology depart ment of Columbia University.

War demands have called for great quantity of oil, and have con sumed huge deposits of metal Geologic explorations have ex panded supplies of both rare an common minerals as well as fuel Professor Kerr said, but serious de pletion of many of the best deposi will necessitate a quest for new sup plies.

The war-time search has deve oped some new exploratory tech niques which still are being ke secret, he added. But the techniqu of the modern scientific "prospecto already included geologic mappin sedimentation studies, geochemic analyses of sands and clays found oil-containing formations, electric logging, seismic waves, the spectro scope, X-ray identification of min erals, and micropaleontology, th study of microscopic life found eve in cores of rocks dug deep from th earth.

Power Plants On Wheels

Comfort in Modern Passenger Trains Requires Large Quantities of Electric Power Put to Work in Many and Divers Ways. On Most Trains, this Needed Energy Is Produced by Car-Mounted Generators Driven by the Axles. Other Methods Are Also Used

By A. G. OEHLER
Electrical Editor, *Railway Age*

PASSENGER locomotives have many functions in addition to hauling cars. One of the most important of these auxiliary duties is the generation of electric power, usually by means of axle-driven generators mounted on the cars.

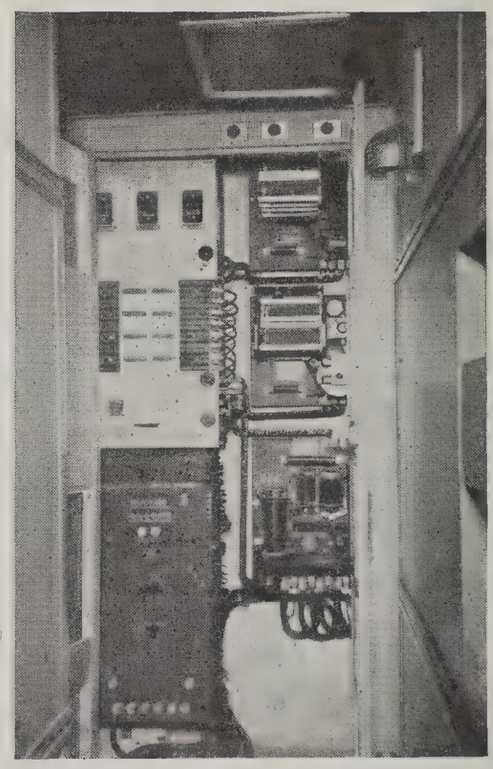
A modern passenger train needs huge quantities of electricity for lights in the cars and on the locomotive; for the ventilation, refrigeration, and controls required for air conditioning; for cab signals or automatic train control; for accurate control of high-speed brakes; for refrigerators and gadgets in the diner; for water-coolers and electric razors in the Pullmans; for the radio in the lounge car; and perhaps also for a train telephone system.

All this necessary auxiliary power is generally created by the locomotive, though on some roads it may be generated by a propane-fueled engine under the car or by one of several Diesel-generator sets in a power car next to the locomotive.

In the United States 6300 steam locomotives are used for hauling passenger trains. This represents about 16 percent of a total of 39,500 used by Class I railroads; 296, or 38 percent, of the country's 868 straight electric engines are used in passenger service; out of a total of 2500 Diesel-electric locomotives there are 287, or 11.5 percent, used in passenger and in combination and freight service. The low percentage of the Diesels used in these categories is explained by the relatively large number used for switching.

Most of the 8729 Pullmans and 35,945 railroad-owned passenger train cars in service today are electrically lighted; 5219 Pullmans and 8139 railroad-owned, a total of 13,358 cars, are air-conditioned. In one form or another, each one of these cars requires from one to thirteen kilowatts of power for the comfort and convenience of the passengers—power that is not used for moving the car.

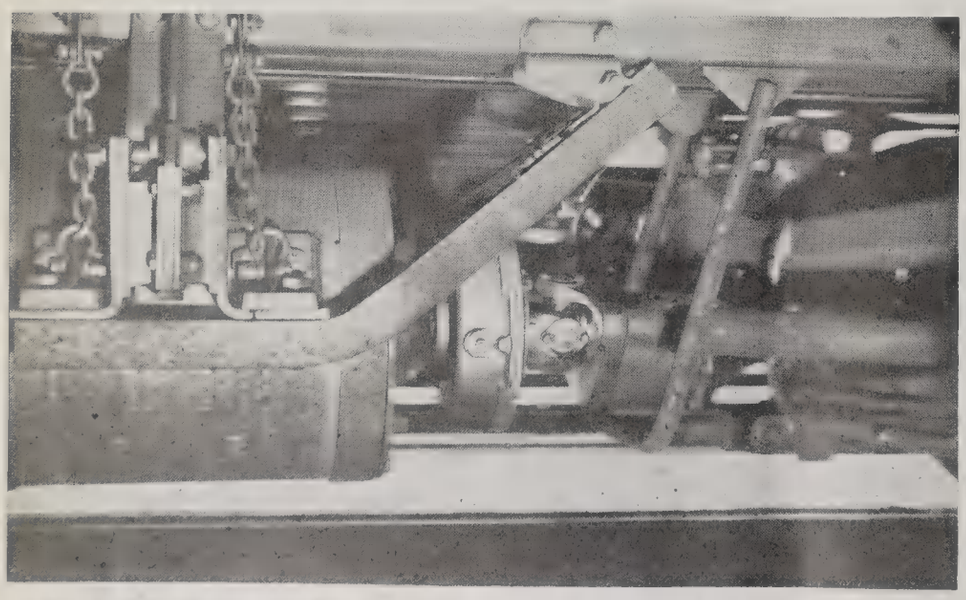
If a car is equipped with electromechanical air conditioning, it has a 20-kilowatt generator driven by gears, or V-belts and gears, from one of the car axles. Although the connected load in the car is only 10 or 12 kilowatts, the generator must be of 20-kilowatt size because the train is standing for a part of the time, or running at speeds too low to develop full generator load. To compensate for this, the generator must have sufficient surplus capacity to charge a storage battery for use when the train is standing.



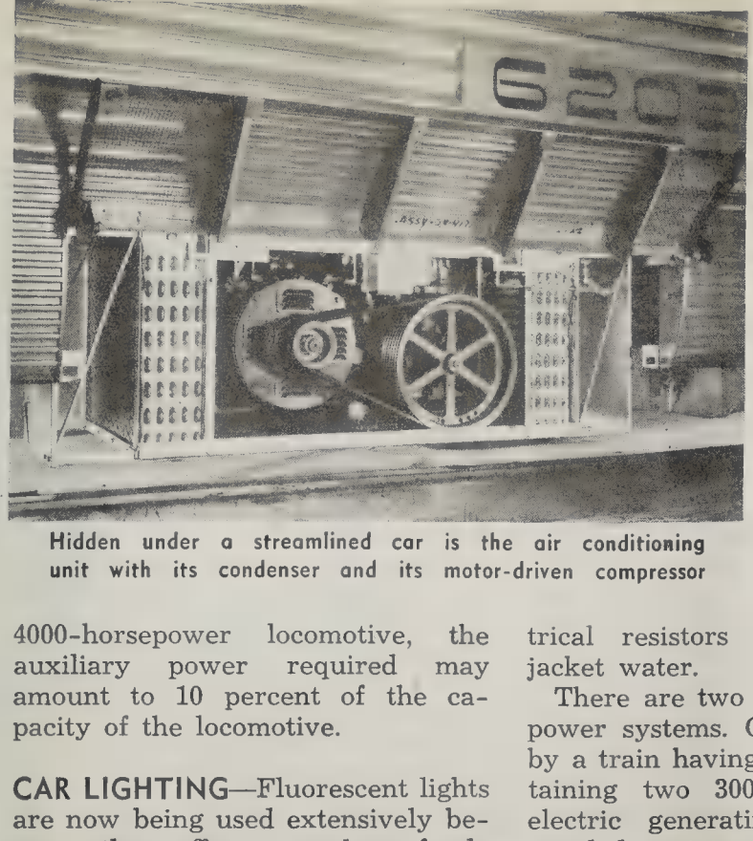
Crowded together in orderly fashion in this locker are all the electric controls of a modern passenger car

Consequently, there must also be standby power systems in yards and terminals for charging batteries and for operating air-conditioning equipment.

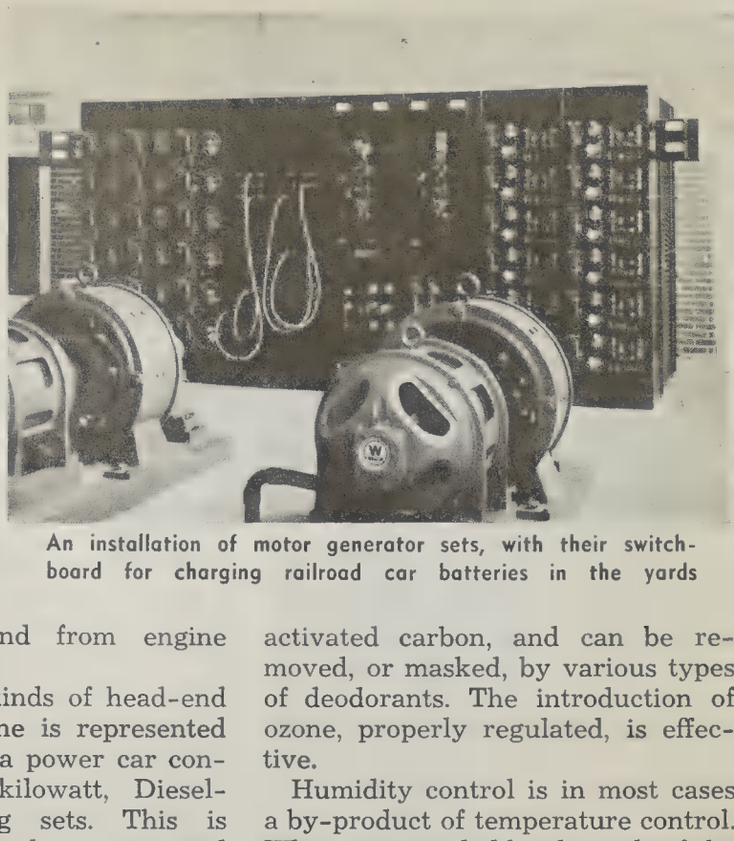
When the 20-kilowatt generator operates at full capacity, it requires about 40 cylinder horsepower of the locomotive. Thus if there are ten air-conditioned cars with loaded generators in a train hauled by a



An axle-driven generator attached to the bottom of a car, showing the automatic clutch, a universal joint, and the splined shaft extending to the gears on the axle



Hidden under a streamlined car is the air conditioning unit with its condenser and its motor-driven compressor



An installation of motor generator sets, with their switchboard for charging railroad car batteries in the yards

4000-horsepower locomotive, the auxiliary power required may amount to 10 percent of the capacity of the locomotive.

CAR LIGHTING—Fluorescent lights are now being used extensively because they offer a number of advantages over incandescent lamps. Their shape makes them readily adaptable to the long, low interiors of a car. They reduce the load on a limited supply system and generate less heat, thus reducing the load on the air-conditioning system.

Most of the available fluorescent lamps operate on 115-volt, 60-cycle power and this means that the direct current from the generator, usually at 32 volts, must be converted either by a motor-alternator or a vibrating inverter. A 15-inch, 14-watt lamp was developed for direct-current operation on 64-volt systems, but its use also requires some loss in a series control resistor for each lamp.

The 32-volt system is most widely used on railroad trains, but growing loads have called for battery sizes which make handling difficult and for unwieldy and expensive conductors. As a result, there will probably be an increasing use of 64 and 115-volt systems.

Engine-driven generators and compressors have found increasing favor on western roads in recent years. In this system, two identical, 20-horsepower, propane-burning engines are used to drive respectively a 7½-kilowatt generator and a compressor to supply the needs of the car, thus relieving the locomotive of the air-conditioning and lighting load.

One train has been built with each car having a power plant which supplies all electrical needs including heating. A Diesel engine under each car drives a 30-kilowatt generator for lighting, air-conditioning, and other needs. When heat is required, this is obtained from electrical resistors and from engine jacket water.

There are two kinds of head-end power systems. One is represented by a train having a power car containing two 300-kilowatt, Diesel-electric generating sets. This is coupled next to the locomotive and supplies all electrical requirements of the train through train lines at 220-volts, three-phase. A 64-volt battery on the power car is charged by a motor-generator set and another on the observation car by a vacuum-tube rectifier. A 64-volt direct-current train line supplies emergency lighting, control apparatus, and air brakes.

The second type of head-end power system is in use on a few suburban trains which are successfully lighted by a steam turbine-driven generator mounted on the locomotive. No batteries are required, but cars cannot be cut out of the train without interruption of the lighting.

PASSENGER COMFORT — Air-conditioning controls on railroad systems are being constantly improved. At first passengers were happy with a little cooling. Having grown accustomed to comfort, however, they became critical. It is now necessary to have controls which modulate the cooling effect in steps, causing the inside temperature to follow the outside at a respectful distance, and keeping all cars in the train at the same temperature. It has also been found desirable to make the controls almost fully automatic.

Dirt is kept out of cars by filters, either the oiled type which is cleaned periodically or the dry type which is replaced when necessary. More recently there has been tested on two cars an electrical precipitator which effectively removes solid particles as small as tobacco smoke.

Odors are another railroad-car problem. These can be absorbed by activated carbon, and can be removed, or masked, by various types of deodorants. The introduction of ozone, properly regulated, is effective.

Humidity control is in most cases a by-product of temperature control. When air is cooled by the coils of the evaporator, water is precipitated on the coils and is drained off. In earlier types of air conditioning, full cycling control was used; the compressor ran at full capacity or it did not run, as dictated by a thermostat. Under these conditions the humidity will rise during off-cycle periods, causing some moisture to form on the skin of passengers even though the rise in temperature is slight. Although rate of air circulation remains constant, when the compressor starts again and the evaporator coils start collecting moisture, evaporation of moisture on the passengers increases and they feel a sensation of cold.

To correct this condition, evaporators are divided into two parts and compressors are run at two or three rates or capacities, thus step-modulating the system to make cooling and dehumidifying continuous at all but very light loads. The ideal condition, however, is obtained by reheating. This requires that the compressor be run constantly at full capacity with a small amount of steam heat used to bring the temperature back to the required value. Reheating has the disadvantage of putting more load on a limited power supply system, but has been used effectively in climates where the humidity is high.

REGULATION—Power control in a car is in all cases centralized in what is known as an electric locker. Here are assembled voltage regulators, automatic relays, main switches, distributor panel, air-conditioning controls, and other auxiliary devices. Unfortunately



Four 50-kilowatt Diesel generators are mounted in this train power car

for the circuit designer, the locker must be placed at one end of the car. From this location conduit lines by the dozens disappear through the floor to the underneath areas and also up into that vast, mysterious, and well-filled space above the ceiling which the passenger never sees. There the electric layout man competes with those who are trying to hide water lines, train lines, brake systems, air piping, tanks, steam lines, and many other things, remembering the while that an adjacent steam line is an effective way to preload a circuit. The modern sleeping car, too, must provide separate rooms complete with all toilet facilities, and is made with thin solid partitions to conserve space.

WHAT'S COMING—Prophecy is always unsafe, but there are already many indications of future trends. The war-time traffic has required that the railroads employ every passenger car they could put into safe operating condition and to use them so intensively that it has often been necessary to turn them around at terminals without sending them to the yards for cleaning. Loading has increased to the point where passengers sit three in a coach seat, with others sleeping in the aisles and even in the baggage racks. Wear and tear has increased accordingly, and the railroads have not yet been allowed to build any new cars.

There are more than a thousand cars on order, waiting until material can be released for their construction, and it is estimated that the passenger train cars to be ordered during the first five years after the war may well approach the total attained in the early 1920's when the average was about 2024 per year.

"Standard Pullmans" with curtained compartments will gradually be replaced with various types of room cars. Many innovations in the form of diners, club, lounge, cafe, and observation cars will appear; even a nursery car has been planned. The preponderance of new cars, however, will probably be coaches since railroads are particularly well situated to supply transportation in large units. The coaches built recently, too, have been notable for supplying more comfortable travel than the chair and lounge cars of some years ago.

Trains will be faster and cars will ride better because of improved design and construction which may even employ such refinements as gyro stabilizers. Electrical operation of service brake applications becomes desirable as train speeds go up. Electrically controlled devices to prevent wheel slipping are used to a limited extent and their application will undoubtedly be extended. Diners will use electric refrigeration and may employ electric cooking; a 50-kilowatt axle-driven generator is being considered for use on a diner. Several designs have also been made for Diesel-electric power plants to supply complete needs of individual cars.

Air conditioning for new and remodelled cars will include many refinements and there will be more automatic control. Models and drawings of new car interiors indicate that new lighting installations may well serve to show the traveling public how lighting can be used advantageously in the home. Gadgets such as grilles, toasters, percolators, mixers, dishwashers, and so on may be expected to appear in considerable profusion. Radio and inductive train telephone systems for communication between opposite ends of a train and between trains, as well as trains and wayside points, will be applied first to freight service, and will later be used to expedite the movement of passenger trains.

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CAR SPRINGS

Studied Through Window In the Car Floor

STANDARD freight-car trucks have coil springs with a maximum travel of 1⅝ inches from free height to solid. These trucks pass through critical speeds usually between 45 and 50 miles an hour where the rate at which the wheels pass rail joints coincides with the natural period of vibration of the loaded truck springs.

The need for longer-travel springs in freight-car trucks intended for high-speed service was established in a series of tests conducted by the Association of American Railroads. In efforts to develop a satisfactory truck conforming to the principles established by the earlier tests, the American Steel Foundries employed two freight cars elaborately equipped with apparatus for the measurement of various truck and car-body movements and of shocks transmitted to the car body. Notwithstanding extensive data available from indicating and recording instruments, visual observation of the action of the trucks was still considered an important part of the tests. Hence windows were placed in the floors of the cars on each side of each truck.

In the development and proof testing of its speed-control truck the American Steel Foundries' cars were run 50,000 miles. The truck includes springs with a maximum travel up to 3-13/16 inches with just enough friction damping action to discourage violent bouncing in the critical speed range.

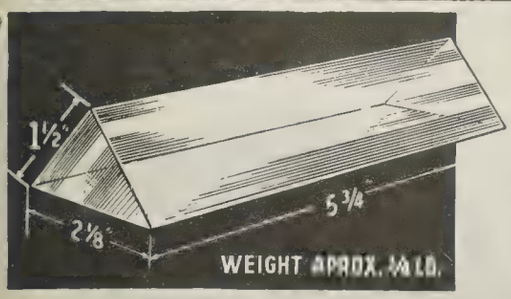
RAILROAD RESEARCH

Coal Mines Take a Hand In Locomotive Improvement

A RESEARCH project to improve the coal-burning locomotive was launched in January by six railroads and three major coal-producing companies. More than a million dollars has been subscribed to initiate the research which will be handled by Bituminous Coal Research, Inc., an agency of the bituminous coal industry, as a distinct project with separate personnel administered by a committee of which R. B. White, president of the Baltimore and Ohio Railroad, is chairman. Bituminous Coal Research, Inc., has under way a study of combustion in the locomotive boiler at the Battelle Memorial Institute.

The railroads involved in the new project are the Baltimore and Ohio; the Pennsylvania; the Louisville and Nashville; the Norfolk and Western; the New York Central; and the Chesapeake and Ohio. They originate more than 60 percent of the bituminous coal tonnage moved by the railroads. The three coal producers are the Island Creek Coal Company, M. A. Hanna, and the Sinclair Coal Company.

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To translate millimeter measurements; 25.4 mm. equals one inch.

8 MM. MOVIE PROJECTING LENS SET — Stock #4011-S . . . $1.20 Postpaid. Consists of 2 Achromatic Lenses, diameter 18 mm. and a focal length when combined of one inch.

SCOOP! CONDENSING LENS SET FOR 35 MM. PROJECTORS OR ENLARGERS
Crown optical glass, unsymmetrical convex, diam. 52 mms. F.L. 88 mm. Set comprises 2 lenses.
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ACHROMATIC OBJECTIVE LENSES with F.L. of 193 mms. Have wider diameter than those used in Army's 7 power binocular. Excellent for telescopes. Diameters of edged lenses are about 52 mms.
Stock #6064-S—Edged and Uncemented—Price $1.75

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These are from the Navy's 7 Power Binocular with 2" diameter objective lens.
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For lenses, Optical inst., etc. Perfect quality — 12 inch Flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
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Stock No.	Item	Price
3006-S	Porro Abbe Prism	$.25 each
3016-S	Pentagon Prism	.75 each
2024-S	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm. — for making Filter)	.25 each
1004-S	4 Reducing Lenses	1.20
3001-S	Lens Surface Prism	2.00 each
503-S	No. 1 Sable Hair Lettering Brush	1.00 doz.
3021-S	Amici Roof Prism (3rd Grade)	.75 each
4009-S	Heat Absorbing Glass 4" x 5"	.35 each
4010-S	Heat Absorbing Glass 2" x 2"	.10 each
2016-S	17 mm. Diam. Gunsight Reticle	.10 each
1020-S	40 mm. Neg. Lens, Cross Lines	.25 each
1070-S	Right Angle Prism 48 mm. wide (3rd grade)	.35 each
523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼"	.25 each
1027-S	Perfect Plano-Convex Lens, Diam. 12.5 mms., F.L. 20 mms.	.30 each
624-S	Neutral Ray Filter size 4¾" x 2½"	.25

(Minimum Order on Above — $1.00)

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1 Red and 1 Yellow Filter in following Diam.

20 mm. (seconds)	40c	31 mm. (seconds)	70c
32.5 mm. (seconds)	70c	45.5 mm. (seconds)	70c
37 mm. (seconds)	70c	29 mm. (perfect)	$1.00

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WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in mms.	F.L. in mms.	Comments	Price
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6111-S	16	36	Cemented	75c
6094-S	16	75	Cemented	$1.00
6066-S	32	132	Uncemented	75c
6115-S	46	108	Cemented	$1.00

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Industry's Permanent Pull

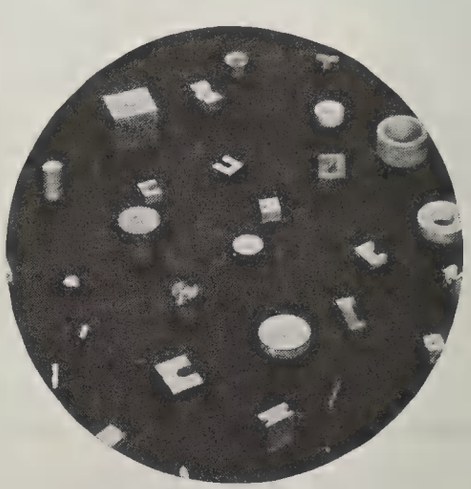
Modern Permanent Magnetic Alloys, Two to Ten Times More Powerful Than Former Materials, are Responsible for Compact, Efficient War-Time Energy-Converting Devices and Will be the Key Elements in Many Post-War Electrical and Electronic Products

ALTHOUGH hardly a new device, the permanent magnet has won so many new friends and entered so many new fields in recent years as to be truly a "modern" electrical accessory. This is especially true of those made of the newer permanent magnet materials, with the unusual design, performance, and cost advantages they provide.

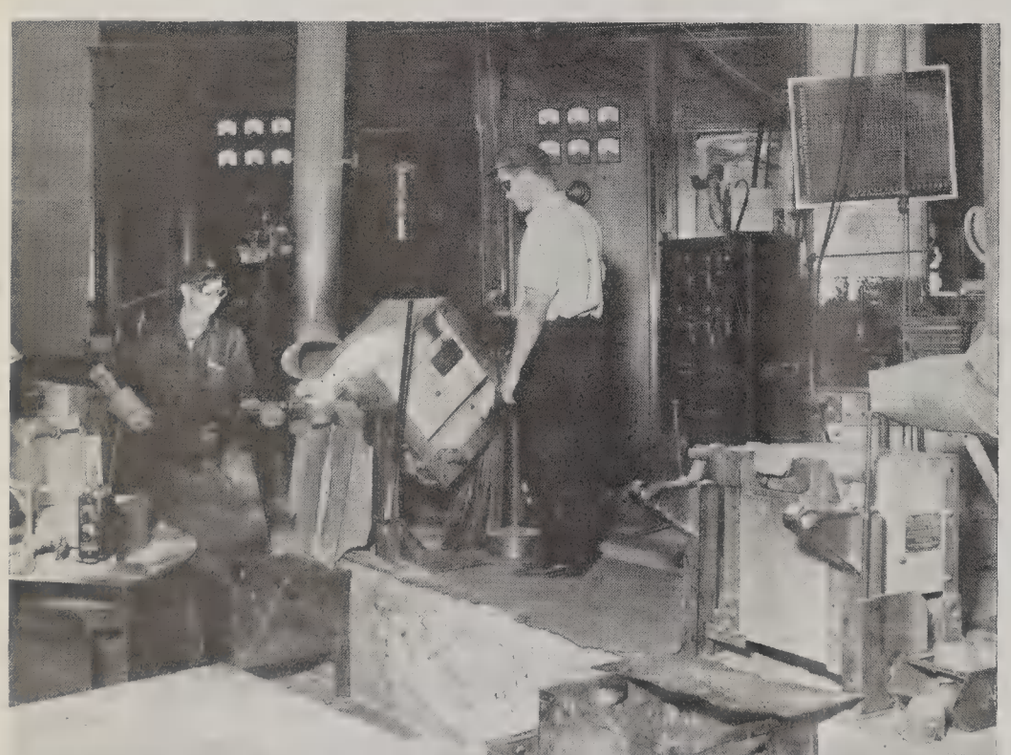
Permanent magnets are the essential components of many of the familiar conveniences of our everyday life as well as of the more utilitarian necessities of industry. Phonograph pickups, radio microphones, electric guitars, automobile magnetos, generators and motors, radio loudspeakers, electric power meters, magnetic separators, magnetic chucks, and thermostats, are among the items of modern living that are more effective because of the highly developed state of permanent magnet materials.

A permanent magnet is a product that retains a large part of the magnetism induced in it when "magnetized" (it has a high "coercive force") and which can then exert a very high magnetic force on other magnetic materials. Permanent magnet materials are said to be magnetically "hard," in contrast to the magnetically "soft" metals like pure iron which are much more easily magnetized (they have higher "permeability") but retain very little magnetic force when the magnetizing energy is removed.

Permanent magnets have been so increased in effectiveness and efficiency in recent years that they are replacing electromagnets in some devices. Nearly everyone has seen, heard of, or wondered about the tiny permanent magnets which can lift 60 times their own weight. Such magnet materials are responsible for some of the most compact and efficient energy-converting devices in war-time use and will be key elements in many of our new post-war electrical and electronic products.



Courtesy General Electric Company
An array of sintered Alnico magnets



These workmen are pouring molten Alnico. High-frequency induction furnaces are employed in this work because they permit close control of composition and cleanliness

The general applications of permanent magnets fall into three major classes, according to purpose: (1) converting mechanical to electrical energy; (2) converting electrical to mechanical energy; and (3) tractive effort—lifting or holding or pushing or pulling materials or apparatus parts.

In converting mechanical motion to electrical energy, the permanent magnet produces a magnetic field through which a moving conductor passes, thereby generating electrical energy (or the conductor may be stationary, with the magnets rotating). The most familiar examples of this are the electric generator, the dynamic microphone, and the phonograph pickup.

In converting electrical energy to mechanical, electric current is passed through a conductor located in the field of a permanent magnet so that whichever is rotatable or movable, moves. Electric motors are a classic example of this, with loud speakers a typically modern use (and prior to the war the number 1 outlet for permanent magnets on an

IT'S UP TO YOU TO HELP MAKE 2=3 WITH...



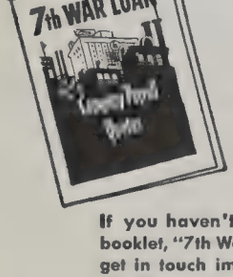
A job for seasoned executives—this 7th War Loan! Especially when we've got to make 2 war loans total just about as much as all 3 in 1944! Putting this over demands the combined and *continued* efforts of the "No. 1" men of American industry.

This means marshaling your plant drive to make every payday—from now 'til June 30th—do its share toward the success of the 7th. Directing the drive is not enough. It's equally important to check to see that your directions are being carried out—intelligently!

For example, has every employee had:

1. an opportunity to see the new Treasury film, "Mr. and Mrs. America"?
2. a copy of "How To Get There," the new Finance Division booklet?
3. a new bond-holding envelope with explanation of its convenience?
4. 7th War Loan posters prominently displayed in his or her department?
5. information on the department quota—and an urgent personal solicitation to do his or her share?

Remember, meeting—and beating—your highest-yet 7th War Loan quota is a task calling for "No. 1" executive ability. Your full cooperation is needed to make a fine showing in the 7th! Do not hesitate to ask your local War Finance Chairman for any desired aid. It will be gladly and promptly given.



If you haven't a copy of this important booklet, "7th War Loan Company Quotas," get in touch immediately with your local War Finance Chairman.

The Treasury Department acknowledges with appreciation the publication of this message by

SCIENTIFIC AMERICAN

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annual poundage basis). Telephone receivers, magnetic recording heads, polarized relays, and similar devices also employ permanent magnets in this way.

TALKING TAPES—Although the Bell Telephone Laboratories has used endless loops of alloy tape for magnetic sound recording for some years in their weather announcing systems, the advent of the war has brought renewed interest in this field. The United States Army is now using tape for recording "on the spot" developments. The records need not be processed but can be played back immediately.

A successful magnetic alloy for this application is "Vicalloy," containing 6 to 16 percent vanadium, 30 to 52 percent iron, 36 to 62 percent cobalt. This alloy holds more permanent magnetism than any other commercial material and, moreover, can be rolled and drawn into a thin flexible tape. A special heat treatment is required to develop suitable magnetic properties.

The third functional field of use—tractive effort—is the one most familiar to the average reader and the one in which permanent magnets sometimes replace electromagnets. Here the magnetic force of the permanent magnet is used directly to attract magnetic material or other magnets. Magnetic chucks for holding work on a lathe and magnetic separators for extracting unwanted iron from nonferrous metal scrap are well-known holding or lifting devices using magnets; a ubiquitous tension-producing application is the thermostat, in which the magnet provides a quick make or break in the electrical circuit without the use of mechanical springs. The packingless drive represents the use of permanent magnets for transmitting motion without mechanical connections.

The original permanent magnets were made of hardened high-carbon steel. Then for many years the best materials were a 3½ percent chromium steel and a 5 to 6 percent tungsten steel. These have been over-shadowed in importance in recent years by the so-called cobalt magnet alloys and most recently by the Alnico materials containing aluminum, nickel, and iron, with or without cobalt or copper.

For reference purposes the properties of commercial permanent magnet materials are given in the accompanying table. The $B \times H_{max.}$ figure is the so-called energy-product of a permanent magnet material and is the usual measure of its efficiency as a permanent magnet. Note the great difference between this value for the older materials at the top of the table and for the more recent alloys near the bottom. Alnico V is a truly phenomenal alloy, being about three times as powerful as any other permanent magnet material.



An Alnico permanent magnet acts as the heart of this radio loudspeaker

PROPERTIES OF COMMERCIAL MAGNET ALLOYS

MAGNET ALLOY	TYPICAL COMPOSITION,%	$B \times H_{max.}$	MECHANICAL PROPERTIES	FEASIBLE METHODS OF FABRICATION
Chromium steel	3.5 chromium, 1 carbon, balance iron	295,000	hard, tough	forged; punched; machined
Tungsten steel	5 tungsten, 1 carbon, balance iron	320,000	hard, tough	forged; punched; machined
17 Cobalt steel	17 cobalt, 1 carbon balance iron	650,000	hard, tough	forged; punched; machined
36 Cobalt steel	36 cobalt, 3.5 chromium, 1 carbon, balance iron	930,000	hard, tough	forged; punched; machined
Cobalt-nickel-copper Alloy	41 cobalt, 24 nickel, 35 copper	993,000	ductile	cold-rolled; machined; punched; cast
Iron-nickel-copper Alloy	20 iron, 20 nickel, 60 copper	1,070,000	ductile	cold-rolled; machined; punched
Cobalt molybdenum Alloy	12 cobalt, 17 molybdenum, balance iron	1,100,000	hard, tough	forged; cast; punched; machined
Alnico I and IV	12 aluminum, 20-28 nickel, 5 cobalt, balance iron	1,250,000-1,330,000	hard and unmachinable	cast; sintered; ground
Alnico III	12 aluminum, 25 nickel, balance iron	1,330,000	hard and unmachinable	cast; sintered; ground
Alnico II	10 aluminum, 17 nickel, 12.5 cobalt, 6 copper, balance iron	1,650,000	hard and unmachinable	cast; sintered; ground
Alnico V	8 aluminum, 14 nickel 24 cobalt, 3 copper, balance iron	4,000,000-4,500,000	hard and unmachinable	cast; ground

MORE POWER, LESS BULK—This extra potency of the modern materials and especially the Alnico alloys has vastly improved magnet design in several respects. A most important feature is the smaller-sized magnets that can be used because of their greater magnetic force, as shown in the accompanying bar chart.

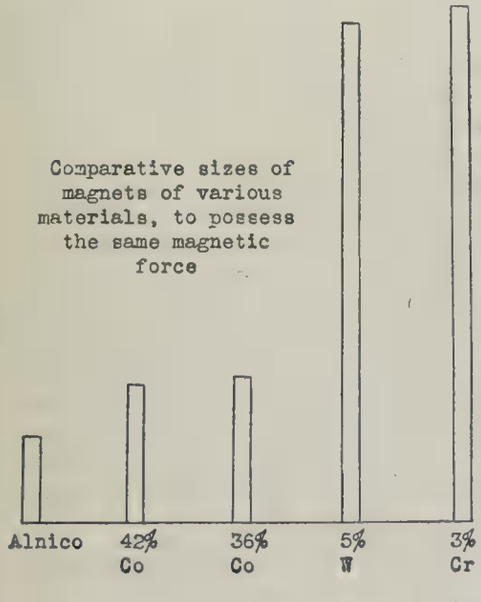
In the case of the newer materials the increase in energy product over the old is proportionately much greater than the increased cost, with a consequent reduction in cost per unit of energy product. Thus the chromium magnet steel may cost three times as much per unit of energy product as Alnico V. On the other hand, such cost-of-performance advantages of an alloy may be partly or wholly offset by the extra cost of fabricating or finishing the magnet itself, since the new alloys are more difficult to work.

The decrease in space required, together with the lighter weight, has frequently justified higher permanent magnet cost. In addition, the Alnico magnets are more resistant to demagnetization (often an important factor) either by vibration or by stray magnetic fields than are the older alloys. The new materials show little loss of magnetic force at temperatures up to 900 degrees, Fahrenheit, whereas the alloy steel magnets suffer appreciable losses as

low as 200 to 400 degrees, Fahrenheit.

The new materials require different production techniques than were commonly used for the alloy steel magnets. All depend for their magnetic qualities on appropriate heat treatment or "age hardening." For the older materials this may be simply quench-hardening; for the newer alloys the magnet is heated to a high temperature to produce a homogeneous structure and then either (1) quenched and held at a dull red heat for a long time to produce a "precipitated" structure possessing optimum magnetic quality (and, incidentally, higher hardness) or (2) slow-cooled from the high temperature to produce the same structure and properties. The second process is more commonly used with the Alnico alloys.

NEW METHODS—The other differences in processing are radical. The tungsten or chromium magnet steel in the form of cut rod or bar is hot-formed to shape on a press, cooled,



Comparative sizes of magnets of various materials, to possess the same magnetic force

drilled, and machined while soft, heated to hardening temperature, quenched and ground to final dimensions. Such methods cannot be used to make magnets from Alnico, for the latter alloys are hard, brittle, unmachinable materials that can be made only by casting nearly to shape and then grinding, or by powder metallurgy methods (pressing metal powders in a die and sintering).

The sintering process is ideal for small magnets of certain designs but has definite limitations above a certain size (about 0.1 pound), and the bulk of Alnico magnets are therefore made by casting and grinding. The magnetic properties of cast and of sintered Alnico of the same composition are about the same. The cast magnets require

(*Please turn to page* 49)



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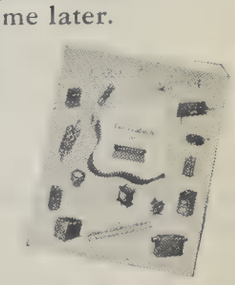
Although specialists in the design and quantity production of transformers for a quarter century, the demands of the past few years have brought about many developments. The requirements for military and essential industry purposes have multiplied many-fold with further emphasis on exactness and uniformity.

Transformer specialists before the War—great strides have been made in anticipating and meeting requirements of greatly varied character that have multiplied many-fold for military and essential industrial purposes.

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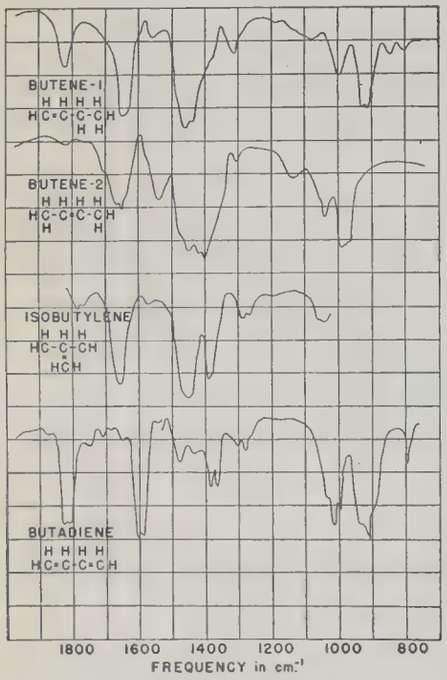
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PIONEER TRANSFORMER MANUFACTURER

Infra-Red In Industry

By Harnessing Forces that Act Outside the Bounds of Human Senses, and Applying Electronic Amplification, Chemical Control Methods Have Been Highly Refined. The Infra-Red Technique is Not Yet in Wide Use, but Successful Results So Far Point to Broad Future Fields

As PROBLEMS of continuous and automatic processing in the chemical industry become more complex, electronic devices grow in stature. In addition to utilizing heat and pressure, control today depends upon factors quite imperceptible to the human senses to motivate operations requiring substantial power in their performance. Forces too faint to be detected by less sensitive means are magnified by electronic circuits until they are able to



Graph of infra-red spectra of a number of C_4 unsaturated hydrocarbons

activate the necessary controlling mechanisms to keep the process within bounds.

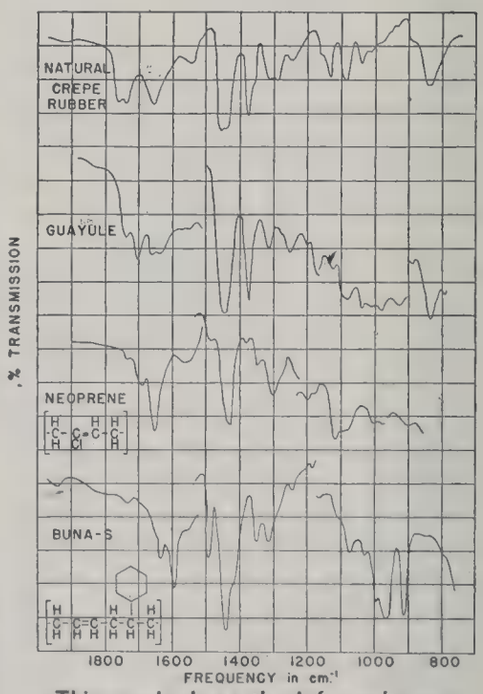
Indeed, the initiating forces may, by their very nature as well as their magnitude, be quite outside the range of our senses and yet be capable of carrying on a chemical reaction in huge amounts of material with far greater assurance than a human operator possibly could. Typical of this class are control functions based upon ultra-violet absorption, pH values of solutions, and infra-red transmission, none of which is normally detectable by the human senses. While the detection and even the measurement of these values can be accomplished without using electronic equipment, conversion of detectors and meters to practical controlling devices requires electronic amplifying circuits.

In this field, the swiftness of scientific development and its application outside the laboratory to plant operating problems are particularly well illustrated. Although many of the basic facts about infra-red absorption and its relation to chemical structure have been known for several decades, their use in the laboratory is still far from general. Only within half a dozen recent years has this technique begun to spread, yet it already has been adapted to the control of important industrial operations.

Current huge scale chemical conversions of the hydrocarbons of petroleum into aviation gasoline on the one hand and into synthetic rubbers on the other have entailed delicate problems of analysis and what seemed only a short time ago to be insoluble problems of control. But both analysis and continuous control of processes have been accomplished with an ease and completeness that suggest further wide applications of the methods employed.

CHEMICAL FINGER-PRINTS—Various hydrocarbons in mixtures can be measured separately by the use of the mass spectrometer, provided there is even the slightest difference in their atomic weights. The method is based on inducing unit electrical charges on the molecules, comprising the unknown gaseous mixture, accelerating the charged particles in an electric field, and finally bending their paths from the normal straight lines by imposing a magnetic field on them. The extent of the curvature of the path is a function of the mass of the particle, as well as its charge, and hence this factor provides a method of distinguishing among the hydrocarbons in a mixture. Furthermore, it is possible—but not yet practicable—to employ this method of effecting an actual separation of molecules of different weights.

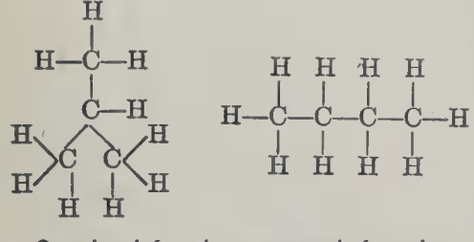
This method, valuable though it is, fails where the hydrocarbons constituting the mixture are isomers having identical molecular weights. Special emphasis is placed on the several hydrocarbons of four carbon atoms in both aviation fuel and rubber synthesis. Obviously, then, a method must be employed which



This graph shows the infra-red spectra of natural and synthetic rubbers

will not only distinguish between the butanes and butenes and other hydrocarbons in such mixtures, but it must also recognize differences between butane (CH_3-CH_2-CH_2-CH_3) and isobutane (CH_3-CH-(CH_3)$_2$), and between the two butenes (CH_3-CH = CH-CH_3 and CH_2 = CH-CH_2-CH_3) and isobutylene, (CH_2 = C-(CH_3)$_2$). Necessarily such distinctions rest on molecular structure alone and their detection can be effected only by a method taking this into account. That is where infra-red absorption finds its natural field because each atomic group within a molecule exerts a characteristic effect on the compound's absorption for infra-red radiation of a characteristic wavelength. The graphic representation of the transmission of infra-red of different wavelengths through any compound is quite as characteristic of the compound as the signature or fingerprint is of a person.

That is particularly important where compounds so similar as the C_4 hydrocarbons are involved. Furthermore, on the basis of differences in the absorption spectra, the relative quantities of each constituent in a mixture can be estimated



On the left, the structural formula of isobutane and, right, of butane

with considerable ease and accuracy. By selecting a particular part of the spectrum (a narrow band of wavelengths) and using it to activate the controlling mechanism, the infra-red transmission of the mixture, and hence the percentage of a particular compound in it, can be used to control the manufacturing process.

Special peculiarity of infra-red radiation is the opacity which many materials exhibit to it. Because many substances have characteristic absorption spectra in this region, particular care must be exercised in choosing the construction materials of the instrument and in excluding any compounds from the path of the rays to be measured that might affect them. Where examinations of organic compounds are to be made, carbon dioxide and water vapor must be carefully excluded from the body of the instrument through which the rays pass or, better, the effect of them allowed for in the result.

The instrument itself consists essentially of a source of infra-red radiation of all wavelengths (a hot body), a sample, a prism for dispersing the rays (made of sodium chloride or other substance transparent in the range of wavelengths being investigated), and a sensitive thermocouple to detect and measure the final radiation. Sensitivity is greatly improved by using concave mirrors to focus and direct the rays and to concentrate the final pencil of rays on the thermocouple for measurement. The voltage generated in the thermocouple by the heating effect of the rays is detected and measured by an extremely sensitive galvanometer from which a graphic record of the transmitted spectrum is taken with the help of an amplifying circuit employing electron tubes.

AMPLIFICATION IS THE KEY— For purposes of control, the intensity of the radiation from a constant source transmitted through the sample at a single selected wavelength is measured by the thermocouple and amplified in an electronic circuit to an extent sufficient to operate the necessary mechanism. The slightest variation in transparency of the sample is reflected in the transmitted beam. Amplification

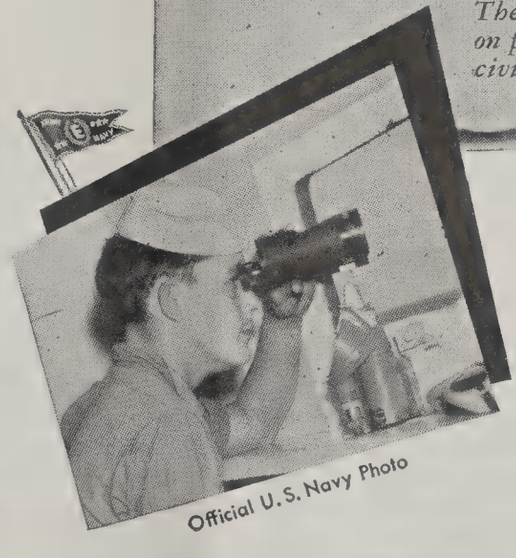
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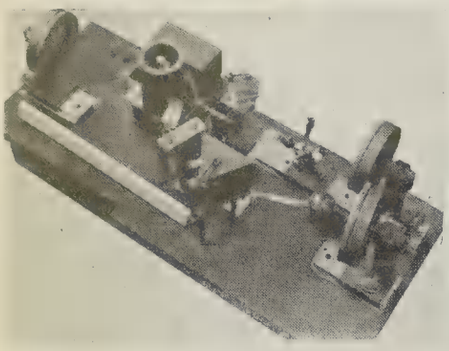
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the feeble initial impulse allows remarkably effective control to be orked out and applied to even the mplicated equipment of both the riation fuel and the synthetic rub- r industries.

Once the transmitted infra-red y has been detected and its effect nplified, the remainder of the ntrolling mechanism and its plan e identical with those based on essure, temperature, and other less struse variables. The objective all such arrangements is to ex-



Infra-red spectrometer without cover

cise control over an operation in ntinuous progress and to make it quickly effective that the process as no opportunity to get out of and.

In the petroleum chemical indus- y, for example, automatic control vital to most processing steps. hese are commonly carried out in ntinuously flowing streams of gas r liquid as they move through eated or cooled zones and past atalysts which influence funda- ientally the chemical changes oc- uring. Because these processes are racticed on a vast scale, the slight- st variation from the established alues for even a tiny interval of me may waste important amounts f materials or even, in the extreme ase, lead to disaster.

The plant operator strives to con- uct his processes at just the point f greatest yield of his desired prod- ct and this may fall on a narrow dge of efficiency between areas of asteful under- and over-conver- ion. This is particularly true with uch delicate reactions as that which onverts various hydrocarbons into utadiene, essential raw material in ynthetic rubber. The desired prod- ct is more delicate and unstable han any of the other compounds kely to be present and hence is eadily destroyed if conditions are ot controlled with great precision n the narrow optimum range.

FFECTIVE INSTRUMENTATION—The same thing is true in varying legrees of all chemical processes. Under one set of conditions they proceed in an efficient and orderly manner and can be conducted continuously with high output. If critical variables are allowed to drift outside optimum ranges, continuous processes become wasteful in the extreme. Seldom can human operators respond with the requisite speed to the demands of the process and hence it is out of the question to attempt to design or operate an automatic or continuous process until effective instrumentation has been developed for it. In this respect, electronic amplification has proved a tremendous boon to the industry. Necessarily the variation of any factor required for control must be tiny to prevent trouble and that requires extreme sensitivity in the controller; but, at the same time, the force required in exercising any control is entirely out of proportion to the power usually available from a sufficiently sensitive unit. That makes an ideal field for electronic amplifiers; industry, made to realize their high value by their performance on wartime tasks, will be quick to use them in post-war operations.

Having used infra-red spectroscopy as an example of electronic control in the chemical industry, it would be negligent not to describe more of the important uses of this valuable tool. A decade ago, infra-red spectroscopy was so unfamiliar to even the scientist that it was considered scarcely more than an abstruse scientific toy. Within the intervening few years, its value has been so proved on both military and civilian problems that few research laboratories will be able or willing to get along without its help. Developments in the instruments based upon it have progressed to the point where simplified models now available are sensitive as well as rugged and sturdy, qualities absent from their earlier prototypes in the scientific laboratories. The present instruments can be readily used in the normal plant environment whereas the older infra-red spectroscopes required to be isolated in a virtual dungeon to get away from disturbing influences.

TIRES ANALYZED—Already mentioned has been the problem of distinguishing between the C_4 hydrocarbons by the infra-red method as one of its outstanding achievements. Quite as striking was its use to analyze tires captured from the Germans to determine their content of natural and synthetic rubbers and the kinds of synthetic used. With infra-red methods this question was settled in a few hours whereas it might have required weeks by other methods, if indeed it could be solved at all. Production of toluene from petroleum has become quite as vital to our war-making potential as that of synthetic rubber. It, too, presented a problem in analysis and control which yielded quickly and easily to infra-red spectroscopy but was extremely tedious and difficult by more usual methods. There are many other examples only a little less striking.

The intricacies of many organic compounds have been revealed by these methods. Each part of the complex structure of an organic chemical compound affects the absorption of infra-red at a characteristic wavelength and thus supplies invaluable clues to the entire structure by showing what parts compose it. The different effects of different atomic groups within the molecule are characteristic and are affected only slightly, if at all, by other groups present. In the hands

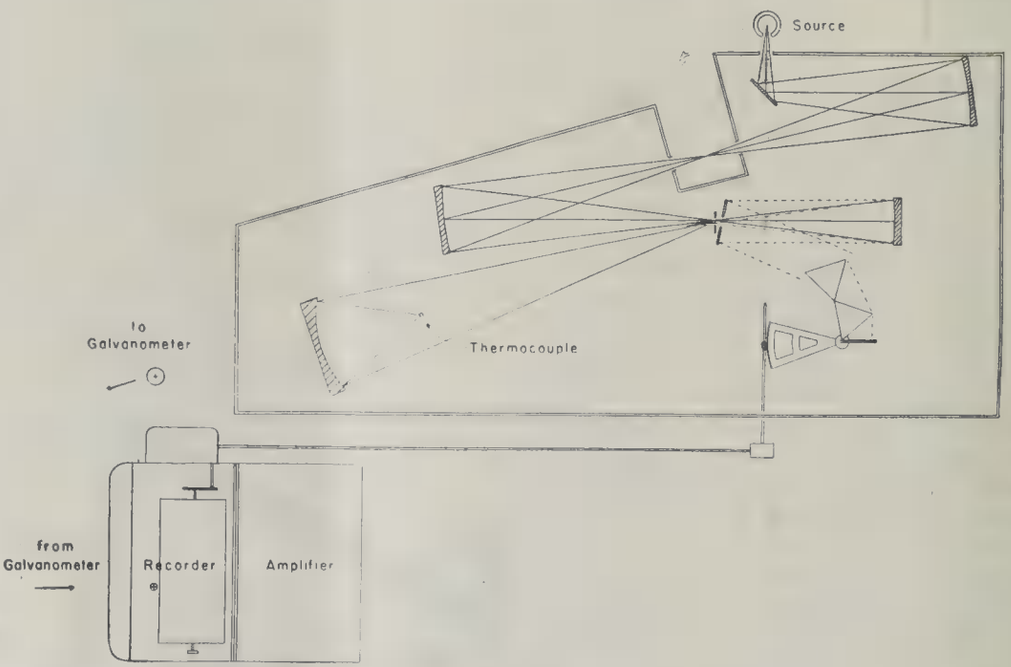


Diagram showing essential parts of an infra-red spectrometer

of an experienced worker, an infrared spectrogram becomes a virtual blue-print of the structure of the compound. The extraordinary variety of the spectra produced by the many thousand organic compounds employed in today's industry makes this the most effective method of distinguishing between them. Furthermore, the known relationships between structures and spectra provide the keys to the mysteries of many new and unknown compounds.

⊕ ⊕ ⊕

PROTEIN RECOVERED

From Still Waste by Use of Waste Lignin

ADDITION of small amounts of lignin from the waste liquor of sulfite pulp manufacture to the waste from alcohol stills operating on grain, precipitates most of the protein in convenient form to filter, according to a recently published research report of the Overly Biochemical Research Foundation.

Distillers have always had trouble disposing of their wastes largely because they contain proteins. But proteins are also valuable foodstuffs. The present technique provides an inexpensive way to remove the valuable proteins from the stillage slops. In a sense it is a case of "setting a thief to catch a thief," since both stillage waste and sulfite liquor are noxious substances, difficult to dispose of. Addition of lignin to the stillage waste causes the protein to precipitate out in an easily handled form for recovery. Not only is food value conserved but pollution of streams by the wastes is prevented.

USEFUL GLYCOLS

Are Bases of Many Drugs and Cosmetics

AN UNUSUAL family of chemicals are the higher polyethylene glycols, with uses ranging from shoe polish to hair dressings, and from medicinals to glazing of china. They are both unctuous and water-soluble, a combination of properties never before available in single compounds, C. P. McClelland and R. L. Bateman explain in a report to the American Chemical Society.

These products are commercially available now in four liquid and five waxlike solid forms, the latter known as Carbowax, and have broad uses in many different industries.

Each is actually a mixture of several polymers and each represents a band of molecular weights. Their properties vary with molecular weights. The melting points, flash points, specific gravity, viscosity, and aqueous solubilizing actions all increase with increasing molecular weight, while water solubility, vapor pressure, hygroscopicity, and solubility in organic solvents generally decrease with increasing molecular weight.

Hair dressings, hand lotions, suntan creams, leg lotions, and skin, powder base, and shaving creams have all been made by leading cosmetic manufacturers from these glycols. A number of specialty creams, including ink removers, are also based on them.

The use of these compounds in pharmaceutical ointments has developed rapidly and shows promise of becoming even larger. Sulfanilamide and sulfathiazole are both soluble in the higher polyethylene glycols. Sulfadiazine and sulfapyridine are less so. Thus, unctuous bases such as Carbowax compound 1500 serve as ointment vehicles for these drugs, while the harder polymers, Carbowax compounds 4000 and 6000, function as dusting vehicles for them.

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Cathodic Protection

Pipelines and Other Underground Metallic Structures are Constantly Subject to Corrosion Caused by Galvanic Currents. Control of Such Corrosion Can be Obtained by the Use of Buried Anodes Which Set Up Counter Potentials. Masses of Magnesium Offer a Ready Solution

By L. H. WOODMAN

MAGNESIUM, the versatile light metal which, after a quarter century of obscurity, bloomed suddenly into wartime prominence and now holds promise of changing many of our established concepts of tomorrow through the reduction of useless weight, is becoming, strangely enough, an ally of steel pipe.

A simple cylinder of the metal, four inches in diameter and 16 inches or more in length, may be the key to saving the nation's consumers of gas, oil, and water millions of dollars annually in costs of replacing and repairing corroded underground pipelines. The results of laboratory research and field tests carried on by The Dow Chemical Company indicate that the use of these magnesium cylinders in cathodic protection of underground pipelines will be an effective and economical procedure and will at the same time offer a substantial market for secondary (reclaimed scrap) as well as primary magnesium.

Gas, oil, and utility companies operate hundreds of thousands of miles of buried pipelines, totaling more than double the combined mileage of all railroads in the United States, and this tremendous network is undergoing constant expansion. While a variety of protective coatings are employed to retard corrosion of these vital and costly lines, pinholes and breaks in such coatings occurring during the laying of the line appear to be inevitable. The method of cathodic protection has been found most effective not only in arresting and preventing corrosion through these pinholes and breaks but also in preventing corrosion of bare pipe.

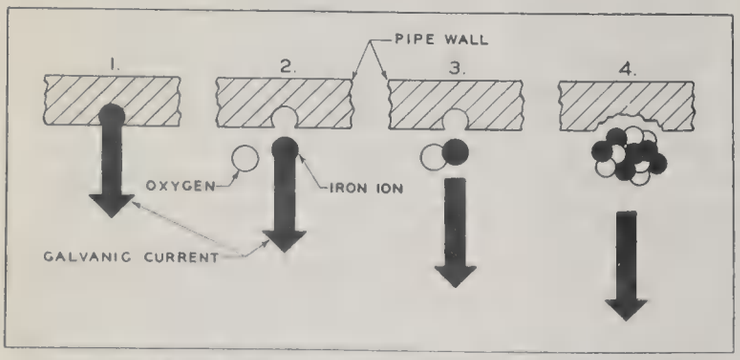


Courtesy Dow Chemical Company

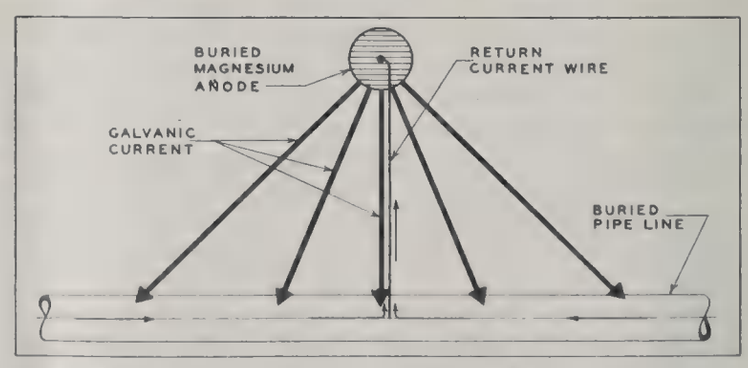
A typical example of a corrosion break occurring at an "anode area" of a steel pipe. The ends of this four-foot length were essentially unharmed

Corrosion of underground metal tanks, foundations, pipelines, and similar structures is engendered chiefly by galvanic electrical currents. Such currents are set up by impurities in the metal, soil variations, and numerous other causes impossible to predict or to control effectively. In this action the corroding areas of the metal assume the characteristics of electrical anodes, the current passing through the moist soil to other areas of the metal which act as cathodes. As the current leaves the surface of an anodic area of the metal it carries with it iron ions which combine with oxygen to form iron oxide. As this action continues a pit is formed which gradually becomes deeper and eventually, in the case of a pipeline or tank, results in leakage as in the example illustrated at the left.

OUTSIDE CURRENTS—It has long been recognized that if these currents could be prevented from leaving the surface of the metal, such corrosion could be prevented. Thus was developed the system of cathodic protection, which involves changing the anodic areas of the buried metal to cathodes by introducing from an outside source a current stronger than the potential in the metal being protected. This idea was first em-



Unprotected iron pipe corrodes quickly when galvanic currents, set up by various causes, carry with them iron ions which combine with oxygen in the soil to form iron oxide



Protection against corrosion is obtained when a magnesium anode sets up galvanic currents which flow into the pipe and oppose the outflowing currents that cause corrosion

ployed by Sir Humphrey Davy in 1823 for preserving the copper sheathing on ships, but only in recent years has the principle been applied to buried metallic structures. Conventional procedure has been to employ an anode of carbon or a bed of scrap-iron buried near the structure to be protected and connected to the positive side of some source of direct current. A return wire connects the protected structure with the negative side of the power source. Thus current is caused to flow *into* the metal through the soil. The potential of this current is sufficient to overcome the potential of outward currents of the galvanic action, thereby eliminating the cause of corrosion.

This method obviously entails some source of power. Where alternating current lines are available, rectifiers may be used. Where no such facilities are at hand, wind-driven or engine-driven generators are commonly employed. However, since extensive pipelines require a series of anodes placed at intervals along the line, this method necessarily involves rather complex and costly electrical installations.

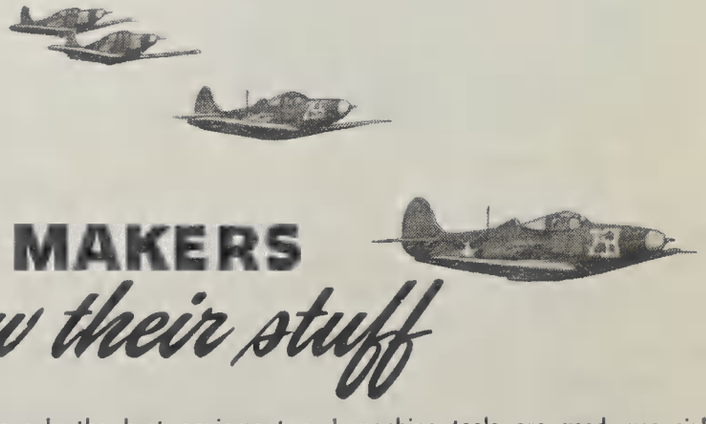
SELF-GENERATED POTENTIALS — A more simple and economical form of cathodic protection, therefore, involves the use of an anode made of some material having in itself a higher potential than the metal to be protected, which will thereby set up its own current by galvanic action without the necessity of an outside source of power. It is this principle which is employed to advantage by using magnesium anodes.

Zinc anodes have been employed in the same manner. They give a driving voltage against iron of 0.4 to 0.5 volts which is generally sufficient to afford protection. Zinc, however, tends to polarize gradually, thus giving less and less protection as time goes on. Because of this factor the degree of protection at any given time after installation of zinc anodes is problematical, polarization not taking place at a constant rate. While zinc of very high purity has shown little tendency to polarize, its use increases the cost of the anodes considerably.

The work done by Dow now shows that anodes of certain alloys of magnesium have a driving voltage against iron of approximately 1.0 volt, or roughly twice that of zinc, that they show no polarization, and that these alloys can be readily and economically cast from either scrap or primary magnesium. While the connecting wires must be welded to the pipe to be protected, the anodes themselves may be put down with a post hole digger or such other convenient means as soil conditions may dictate. Skilled electricians are not required as in the case of the outside power installations and the actual costs of the magnesium anode installation are relatively low.

ALL UNDERGROUND — Another factor in favor of both zinc and magnesium anodes is that there need be no equipment, or even wires, above ground to invite vandalism. That this seemingly insignificant point can be a matter of real importance is illustrated by the wryly amusing story told of a firm having extensive pipelines running through a remote section of South America. Wind-driven generators, employed with scrap-iron cathodes, kept disappearing and replacement was becoming a substantial cost item when the company's engineer discovered that members of the native tribes simply did not "rate" unless they had one of those "windmills" to decorate the front of their hut.

Magnesium anodes have been cast principally in 14-pound cylinders with six-foot lengths of wire cast into one end for making the connection to the pipe. Such factors as depth of installation, distance from



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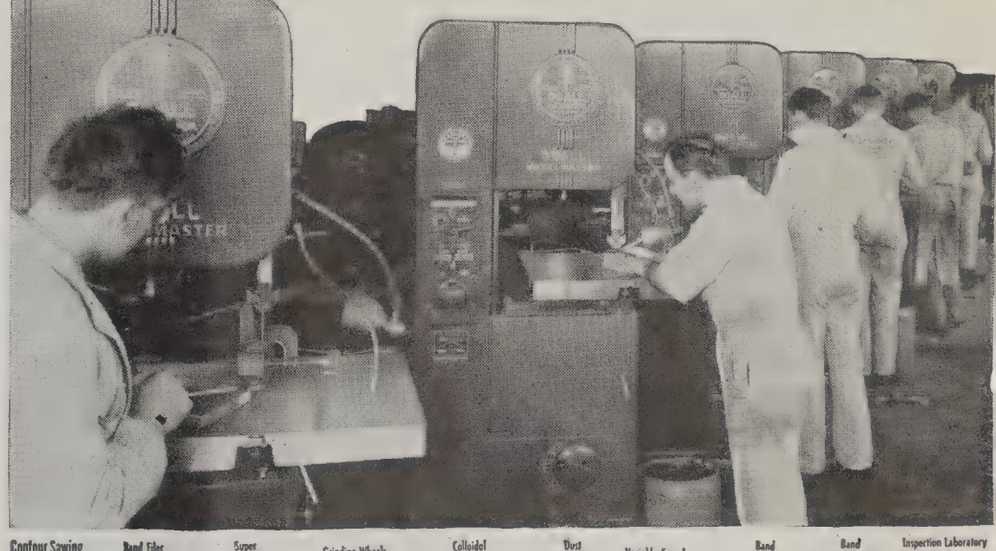
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Courtesy Dow Chemical Company
Cast magnesium anodes

pipe and spacing along the line are dependent upon soil conditions, protective coating of pipe, and many other variable factors which must be determined in each case by corrosion engineers. The service life of a given mass of magnesium is likewise governed greatly by soil conditions, and it appears likely that anodes eventually will be cast in a variety of weights so that the corrosion engineer will be able to obtain sizes calculated to give, for example, two years, or five years, or perhaps ten years of service under known soil conditions. Various shapes and core arrangements are also under investigation. The 14-pound cylinder might be said to have a service life of approximately four years under "average" soil conditions, although corrosion engineers will hasten to declare that there is no such thing as an "average" soil.

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CORROSION LOSS

Rated as 2 Percent Annually of Iron and Steel

APPROXIMATELY 2 percent of the total weight of iron and steel in use in this country is lost annually due to corrosion and must be replaced, according to Dr. Hugh McDonald, director of the corrosion laboratory recently established at Illinois Institute of Technology. "That percentage is an important item in war time. Through research we are attempting to cut the loss."

The only educational and research center stressing corrosion in the United States, the laboratory will carry on a basic, long-range research program on the fundamental theory of the mechanism of corrosion processes and control, and will serve as a center for graduate instruction in the science and engineering problems of corrosion.

Dr. McDonald adds that the problem will become of even greater importance in the post-war period when thousands of tons of intricately-built equipment will be stored in government warehouses for periods of from 30 days to perhaps 20 years.

POWER TRAINS

Generate Electricity Needed At Fighting Fronts

MOBILE electric power trains are one answer to pushing back the enemy and "setting up shop" in the midst of blown-up power plants. By the use of railroad cars of special design mounted on standard trucks, tanks, trucks, and other war equipment can be repaired close to the front. The idea, an American one, has been a god-send to the Russians.

This portable power comes in the form of a train of 10 railroad cars easily transported to devastated areas to provide power and light within a few hours. Specially designed steam boilers are being made for mobile power units at The Baldwin Locomotive Works. The boilers are shipped to the American Car and Foundry plant, where they are mounted on cars with other apparatus supplied by General Electric and its subcontractors and shipped as an assembled power train.

Each power train consists of two boilers, two tenders carrying coal and water, one car containing auxiliary equipment, another containing the main turbine, generator, and surface condenser, and three cars containing equipment to cool condenser water. In actual operation a tenth car is added to serve as crew quarters.

These mobile power plants on their own wheels are hauled by railroads to the site, spotted on a single track and need only the connection of steam pipes, water pipes, and electric cables, all carried on the cars, to be ready for operation.

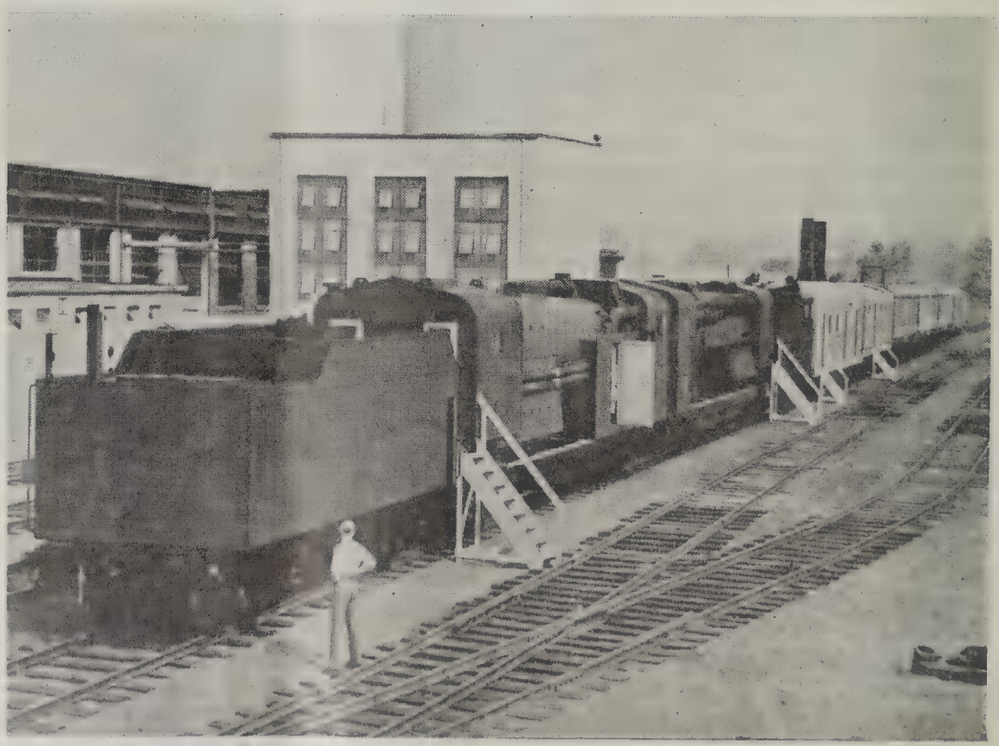
The power train is designed for a continuous output of 3000 kilowatts, using coal having a heating value of less than 7000 B.t.u. per pound. This heating value is much lower than that of the poorest grade of coal obtainable in the United States.

COLOR CONDITIONING

Of Industrial Interiors Brings Higher Production

FUNCTIONAL color for industrial interiors to improve employee efficiency, health, and comfort will be a post-war reality. Described as the science of determining the correct industrial color environment for maximum vision, the system has been developed by Du Pont in collaboration with Faber Birren, leading industrial color authority. Among the benefits of "color conditioning" are listed increased production, improved quality of workmanship, and reduced personal injuries.

The technique is designed to protect employees against eyestrain by reducing glare and eliminating extreme contrasts between light and dark. It recommends restraint in us-



Special trains can furnish emergency power where needed

ing color, especially distracting, over-stimulating hues, as well as abolishing light-robbing and dangerous dark areas.

Research findings have determined correct colors for factory walls, for machines, and for backgrounds within the field of vision. Surveys of entire plants where an integrated color system has been put in effect from front to rear door demonstrate that uniform wall, dado, and equipment painting, with a "change of pace" for corridors, stair wells, and washrooms, yield beneficial results as revealed in comparative safety, production, and absentee records. Only a few colors in combinations need be utilized, the studies show.

New colors have been developed for industrial interiors. These are not decorator's colors in the bright, clear range, but hues subdued in tone and unobtrusive and practical. In selecting the colors, illuminating and color engineers studied light-reflectance qualities, hue characteristics, influence of different kinds of illumination, and psychological characteristics.

PLANE ENGINES

Will Be Carefully Chosen
To Give Greatest Safety

EXTREME care in the selection of aircraft engines to fill specific needs in post-war operations will be required by new standards of service and safety in commercial air line operations, according to Charles Froesch, chief engineer of Eastern Air Lines.

"While the air transport operator," says Mr. Froesch, "is reconciled to the thought that the conventional type of reciprocating internal combustion engine will be used for several years more, he is, nevertheless, following the development of the gas turbine with interest. Its simplicity and relative ease of installation are tempting characteristics, but its low thermal efficiency, as reflected by high specific fuel consumption, is at present a serious disadvantage. This will undoubtedly be overcome by the development of materials which can stand higher operating temperature, but with them may come greater difficulties of thermal nature, which engineers have been trying to remedy in the present type of engines.

"Transport aircraft designed before the war," Mr. Froesch continues, "as a result of air-line operating experiences with the Douglas DC-3's for many years, were put in mass production during the present conflict and utilized far more than was anticipated. These aircraft have been operated with loads and at speeds which were not thought to be safely possible. Operational characteristics have been developed and experimental testing of newer equipment indicates that we have grown technically to a point where our pre-war thinking must be adjusted."

Mr. Froesch goes on to say that there is general agreement that two engines are the minimum requirement for flight safety, since the carriers will be flying in more difficult weather than heretofore. Size of the engine selected depends to a large degree on the total number of engines used and the type of operation for which a plane is designed, he adds, noting that under Civil Aeronautics regulations twin-engine planes are required to develop higher total take-off power than planes equipped with four engine power-plants.

GOOD FROM WAR

Seen by Scientist
In Optical Appliances

SEVEN WAR-TIME optical inventions which have important post-war applications are cited by Dr. E. L. Tillyer, research director of the American Optical Company, as concrete evidence that some good has come out of the tragedy of war. The inventions, he says, were develope



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to fill certain military needs and are now aiding the war effort. They include:

1. A new method of reducing light reflections, useful in removing annoying or dangerous glare from auto windshields, shop windows and cases, paintings, photographs, and instrument and camera lenses. 2. New charts for testing color blindness, which makes the United States independent of Germany and Japan, previous sources for such charts. 3. New types of sun glasses and goggles which provide maximum eye comfort outdoors by absorbing annoying glare and invisible rays. 4. A new all-plastics artificial eye which rivals a human eye in color and appearance, resists breakage and corrosion, and can be re-shaped to fit the eye socket precisely and therefore comfortably. 5. A new absorptive welding glass which permits gas welders to look through blinding glare and see welding operations, thus speeding production and protecting eyes. 6. A new glass which offers resistance to hydrofluoric acid which disintegrates ordinary glass. It is useful for safety lenses and laboratory glassware. 7. A new process of annealing or heat-treating optical glass, which stabilizes the glass and makes possible improved types of lenses.

ALL-WELDED HOSPITAL

Will be Erected When Materials Are Available

PRELIMINARY details have been worked out for what is believed to be the first all-welded hospital building in the country. The 18-story structure embodies the most progressive ideas in modern design and furnishes a significant clue to the general type of building construction that can be expected as soon as restrictions on material are lifted.

It is proposed that the framework of the new unit, to be known as Kahler Hospital, will be designed as a continuous structure of beams and their connecting members, welding details of which are based on past analysis and conform to general engineering acceptance.

In preparing the specifications, the architects, according to the Lincoln Electric Company, discarded all concepts of riveted construction, which tends to restrict the range of application of certain welding details.

The hospital building, to be erected at Rochester, Minnesota, will cover an area of 150 feet by 270 feet, or about half a city block, and will be built of welded steel with concrete floor slabs.



Sketch of the proposed hospital in which the framework will be all-welded

WEATHER MACHINE

Creates Rain and Sunlight To Test Materials

KNOWN as a weather-ometer, a new machine provides conditions equivalent to sunlight at noon in June, and a water spray of varying intensity to simulate rain. It allows the effects of sunlight, periodic rain, and temperature changes on a material under test to be determined in advance.

Light and water spray periods are automatically controlled. Interchangeable nozzles determine the volume of water delivered, with the material under test controlling which shall be used. One of the automatic controls allows the light to remain on for the test period and drenches the material with water for three minutes every 17 minutes. Other controls permit interruption of the light and starting of the water spray at intervals.



Inserting a test sample of material in the new "weather-making" machine

One of the major tasks of the machine as used by B. F. Goodrich is to evaluate the weathering ability of Koroseal to see that it measures up to specifications.

ACTIVATED CARBON

Has Extended Surface For Chemical Absorption

A CHEMICAL cousin of both diamond and coke, activated carbon is a powerful tool of many increasing uses, ranging from life-saving service in gas masks to salvage of a host of valuable materials. A smooth, solid, one-inch cube of chalk has a surface of six square inches, but "the same weight of the best activated carbon possesses an available surface of 59,400 square yards or about 12 acres," Drs. Ernst Berl and Walter G. Berl of the Carnegie Institute of Technology explain in summarizing research in this field.

Activated carbons can be tailor-made to fit various needs, and the large, pitted, and porous surface "is a powerful tool for the adsorption, elimination, or recovery of a host of desirable and undesirable substances.

"Most war and industrial poisons in concentrations that would be immediately fatal if inhaled are filtered out completely in less than 1/100 second contact.

"Valuable solvent vapors, as ether and alcohol in the production of rayon or smokeless powder, which are carried off by air during the drying operation, are completely recovered on passing through beds of activated carbon. They can be separated and revived by extraction with live steam. Similarly, valuable liquid gasoline fractions in natural gas or benzene in coke oven gas can be separated conveniently."

(*Continued from page 39*)

especially close control during the melting and pouring operations, with induction heating equipment virtually essential.

A very recent development holding much promise for the production of Alnico magnets of larger size and greater intricacy is the use of the precision ("lost wax") casting method for making such magnets. This overcomes the machinability limitation by permitting the direct casting of the magnets to very close dimensional tolerances and with satisfactory magnetic properties.

Thus we see modern methods—powder metallurgy, induction melting, precision casting—coming to the aid of a new material whose potentialities could not otherwise have been fully utilized because of normal processing limitations. We may confidently expect continued improvement in permanent magnet materials and a steady expansion in their overall use in electrical and electronic equipment.

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CORROSION PROTECTION

Afforded to Steel by Silver Cladding

ADD TO the modern clad metals with bright possibilities for the future silver-clad steel used in chemical and petroleum industry equipment that will handle hydrofluoric acid in high octane gas production and also resists chlorinated solvents. Silver-*clad* steel is superior, it is said, to silver-*lined* steel because the former has better heat conductivity.

INDUCTION HEATING

Has Great Advantages In Metal Forging

LARGE-SCALE application of the induction method to forging-heating has shown a particularly rapid trend during the war. Because induction heating is at its best in high-production applications, it was the obvious selection for a large part of the war-born forging capacity of the nation. This trend was accelerated both by the lack of skilled forge-plant help and by the opportunity to build new plants and install new forging capacity without having to write-off existing facilities.

A recent survey of operating conditions has turned up some interesting data. For example, induction heating produces virtually no scale, while furnace heating produces scale amounting to as much as 6 percent of the total weight of the heated piece; the elimination of scale not only saves metal but often extends die life 300 to 400 percent.

Again, heating times are very rapid: A 1⅜-inch diameter steel bar comes up to 2300, Fahrenheit, in eight seconds and a 3-inch diameter bar in two minutes, by induction heating, whereas much longer time would be required by ordinary methods.

When heating bar stock larger than ¾-inch in diameter it is possible to use the lower frequencies produced by motor-generator sets rather than spark-gap or electronic oscillators. Bars larger than two inches can be economically heated for forging only with frequencies as low as 960 cycles per second.

An interesting point is that, although the electrical efficiency of heating nonferrous metals inductively is less than that for steel, the power requirements to heat to forging temperatures are no higher for the nonferrous metals—simply because the nonferrous metals have lower forging temperatures; they do not have to be raised to as high temperatures as steel.

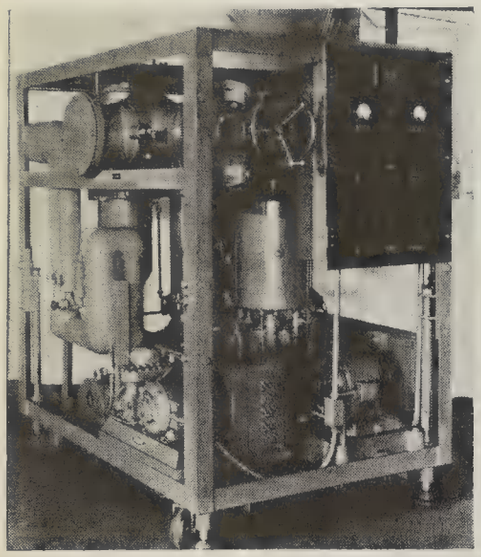


New Products and Processes

VACUUM PUMP

In Compact Unit, Easy to Use

COMPLETE high-vacuum pumping systems, in new compact units for direct connection to the vacuum lines to be evacuated, are now available in various capacities. Each consists of a mechanical forepump, diffusion pump, high vacuum valves, gages, and control



Packaged vacuum pump, on casters

panel. Mechanically refrigerated traps are built in on special order.

These unit systems are simple to operate and eliminate the necessity of setting up complicated high vacuum pumping systems. Only one connection is necessary. The unit is fully automatic and incorporates various safety and protective features. Vacuum conditions are indicated continuously on the control panel, and recorders may be used.

Development of these "package-type" vacuum-producing units is credited to the Vacuum Engineering Division of National Research Corporation.

GIANT LENS

May be Used in Aerial Map-Making

A PHOTOGRAPHIC lens with a built-in heating system has been designed for the Air Forces and soon may be produced by the Eastman Kodak Company. The lens is a 48-inch monster for aerial photography, and the thermostatically controlled electrical warming device in the mount will operate when the lens is used in the cold upper regions. Without it, the metal of the lens mount would shrink enough at low temperatures to throw the lens out of focus.

By interlapping successive "shots" taken at heights of eight miles or more with the new lens, 9-by-18-inch pictures can be made into a giant-size map of a countryside that will reveal detail far more clearly than pictures previously taken at the same altitude. When used with infra-red film, the new lens is expected to aid greatly in the detection of camouflage. Its use with color film will help to point up obscure detail.

DOUBLE FLARING

Made Easy with New Machine

A DOUBLE flaring or lapping machine, developed at the request of aircraft manufacturers, is expected to have wide application in industry. It produces a double thickness of metal on flanges or flares, thereby enabling the tube to hold a much greater working pressure and to have greater resistance to failure at the connection.

Manufactured under the trade name of Tube Master by the Leonard Precision Products Company, the machine is simple in operation and requires little skill. No hand tools are necessary.

To change the size of dies, the operator unscrews the face plate and inserts the proper size dies. The tool bar slides out of the head for change of punches. While the machine is intended for nonferrous tubing sizes ⅛ inch to ½ inch, special dies can be furnished to handle annealed ferrous tubing, sizes ⅛ inch to ⅜ inch. Model DF, now available, is entirely pneumatic in operation, requiring an average of 100 pounds air line pressure.

PLASTICS COATINGS

Preserve Wine Flavor, Prevent Corrosion

PLASTICS protective coating may be responsible for a natural taste in wine and brandy which otherwise might acquire cloudiness and metallic flavors from storage in bare steel or concrete vats. Other coatings of the same plastics family keep aviation gasoline, stored in concrete tanks, similarly free of contamination, while still others protect the outer parts of steel ships from the action of sun, wind, and wave. In the same way, the steel water control gates of giant canals are preserved from the destroying effects of the acids and minerals in the water and alternate wetting and drying in the hot sun.

Producers of wine and brandy were among the first to discover that "Vinylite" plastics coating, developed by American Pipe and Construction Company, would prevent contamination by iron or calcium salts from the steel or concrete of the tanks in which they were made and stored. These same resins have alleviated, if not removed, the corrosion and contamination problems of the fuel and fish storage tanks of tuna clippers. These tanks are alternately filled with fuel oil on the trip out to the fishing grounds and with refrigerated salt brine and fish on the way back. The combination of alternating exposure to fuel oil, salt brine, fish oils, and freezing temperatures, and the abrasion caused by the rubbing of the fish, is a severe test for any protective coating.

Aviation gasoline will seep through all except the most impermeable materials; but, even more important, if aviation gasoline remains in contact with alkaline concrete for long periods of time, such as when it is being transported in concrete ships, it will become unstable because of the reaction of its stabilizer with concrete. Steel boot-topping strips on fast liners are about ten feet wide and extend around the hull at the water line. The steel is thus exposed at different times to sun, wind, waves, and physical abrasion. The plastics coatings that protect this critical area similarly protect the steel of the water-controlled gates on the Gila and All-American canals in Arizona and the Imperial Valley in California, among others.

INSECTICIDE

Made Synthetically For Garden Use

A POWERFUL synthetic insect-killer promises this season to meet United States vegetable growers' urgent need for an insecticide to replace the war-scarce rotenone, pyrethrum, and nicotine sulfate used to control aphids,



Sucking insects, such as these black bean aphids, are reported to be controlled by a new synthetic insecticide

leafhoppers, and other insect pests. Known as Lethane B-71, it has undergone four years of extensive field testing on tomato, pea, bean, spinach, and cabbage crops by large growers and State Experiment Stations. For the control of sucking insects on these essential crops, the chemical has demonstrated a killing power equal to nicotine, rotenone, and pyrethrum.

Vegetable growers who have depended on these imported materials to protect their crops from sucking insects—those which draw juice from the plant and are killed only by a powerful contact poison—are welcoming the synthetic toxicant developed by the Rohm and Haas Company.

BOTTLE WATCHER

Automatically Rejects Those With Flaws

A DECIDED benefit to food processors and consumers alike is seen in the development of a photoelectric crack detector that inspects glass jars and bottles as they pass on a rotary turntable, automatically singling out and rejecting those that contain minute cracks or surface irregularities. Such flaws, if they were to pass unnoticed, might prevent airtight sealing and result in spoilage of the contents.

This crack detector is more accurate than a human inspector in uncovering defects in glass containers and is much more rapid. Inspecting bottles as fast as they are made on a bottle-making machine, which may be one or more every second, it detects flaws barely visible to the naked eye. General Electric, in collaboration with the Hartford-Empire Company, developed the machine especially for use in food packaging plants. In one such plant it was previously found that, on the average, two out of every 100 glass containers with flaws escaped detection by human inspectors.

In operation the detector rejects faulty containers without interrupting the continuous bottle making process. As the containers automatically move in front of a sensitive photoelectric tube, they are whirled rapidly while a strong light is directed on the part to be inspected. Since the phototube is not affected by a steady light, the light reflected by a perfect glass produces no effect. A rapidly spinning bottle with even the slightest imperfection on the sealing edge, however, causes the light beam to flicker, and this quick change in the intensity of the beam is sufficient to eject the imperfect container while the perfect ones are allowed to continue on their way.

SAFETY CLOTHING

Standards Improved to Protect Workers

ASBESTOS clothing fabricated according to new American war standard specifications will lessen the menace of radiant heat and molten metal splashes for steel mill and foundry workers. These standards cover asbestos aprons, cape sleeves and bibs, leggings and coats—garments that are used widely in industry to provide insulation against extreme heat during the course of the day's work, and protection against sudden splashes or spills of molten metal that may mean painful "lost time" burns or even death. Whether splashed asbestos coats, leggings, or sleeves will scorch slowly enough to give their wearers time to get out of danger and remove the garment and whether the smoldering garments can be quickly shed are of vital importance.

For these reasons, the quality of the asbestos and the design of the garment were chief considerations of the subcommittee of the American Standards Association that drew up the new standards. Only second in importance, however, was the need to conserve scarce materials depleted by wartime demands.

Among the problems that confronted the committee was the fact that few scientific tests for wearing or fire-resistive qualities of varying grades of asbestos had been made, and the fact that nearly all available cloth was needed by the armed Forces, making it necessary to use efficiently what asbestos cloth there was. Scientific data on which to base these standards was obtained with the aid of the National Bureau of Standards which carried out tests for the fire-resistive quality of varying grades of asbestos cloth.

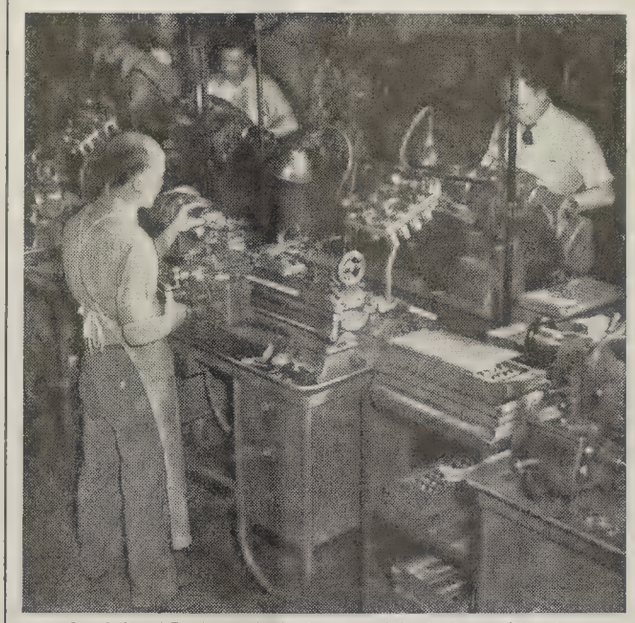
Altogether, there are four separate standards. The first one covers the widely used bib type asbestos aprons. Only plain and split-leg types of apron are included in this standard since, in the opinion of the committee, these will service industry adequately. In addition to the minimum requirements for the material—weave, yarn ply, thread count, grade of asbestos, weight of cloth, and breaking strength—methods of test for the asbestos content, water of composition, weight of the asbestos cloth, and breaking strength of the cloth are included. When leather is used in reinforcing the asbestos garments, tests are specified for grease content, chromic oxide, acidity, heat resistance and shrinkage, and thickness



FOR EXACTING OPERATIONS

IN ELECTRICAL DEVELOPMENT AND MANUFACTURE

Pre-Production work at Bell Telephone Laboratories on a South Bend Lathe



Perhaps no class of machine work demands greater precision than is required in the development and manufacture of electrical equipment. Because of their sound design, versatility, and unfailing precision, South Bend Lathes are extensively used in experimental and research laboratories for the development of electrical equipment, and in manufacturing plants for production of electrical devices of all kinds.

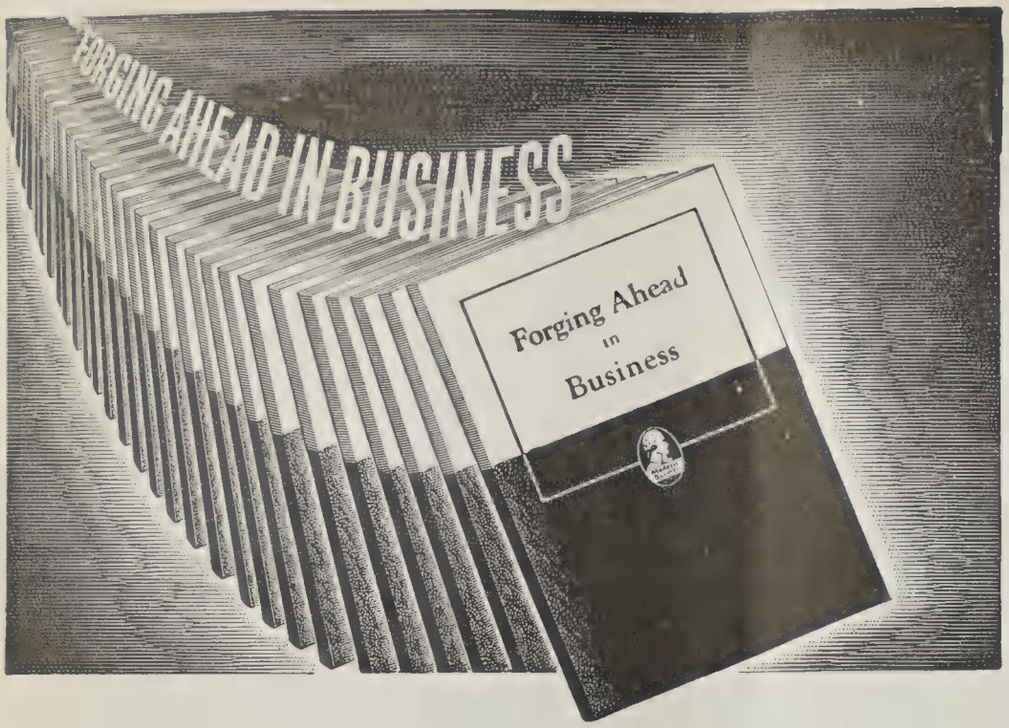
South Bend Lathes are made in five sizes, 9″ swing to 16″ swing inclusive. A complete line of practical attachments simplifies tooling the lathes for many kinds of operations. Write for Catalog 100-D.

A South Bend Toolroom Lathe in use at Westinghouse Electric and Mfg. Co., Springfield, Mass.

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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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of the leather. A corrosion test for hardware, such as metal fasteners for the aprons is included.

Specifications for cape sleeves to protect arms, shoulders, neck, and upper chest are outlined in the second standard. These include plain cape sleeves. Different sizes for men and women are listed. Sleeves are designed to reduce the bulkiness of the asbestos at the fold of the arm. The shape of the garment is specified, as well as seams, stitching and edges, rivets, and hardware.

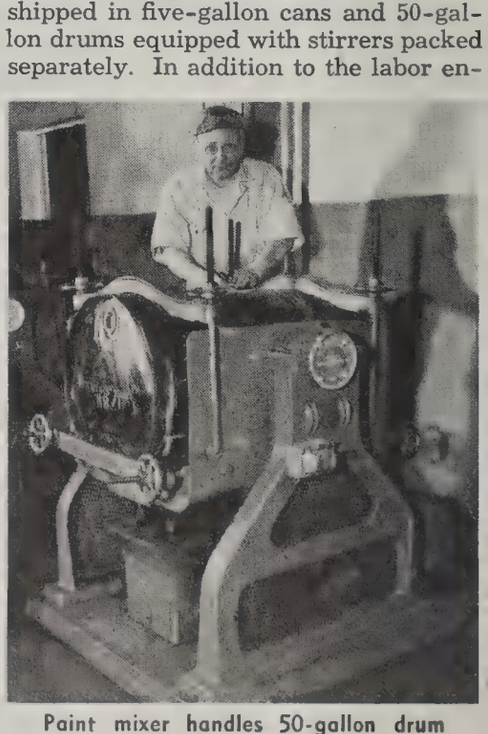
The standard for knee and hip-length leggings in men's and women's sizes gives specifications for wrap-around and spring types in both knee and hip-length leggings, and in the pull-on type for hip-length leggings. The method of fastening is specified to facilitate removal. The coat standard provides one type of asbestos coat in hip, knee, and ankle lengths. Because asbestos, unlike leather, comes in regular widths, not more than three pieces of asbestos may be used in the coat, exclusive of the sleeves and collar, and not more than two of these pieces may be used for the entire front. Thus the back of the asbestos coat must be made in one piece, whereas in the case of leather coats more than one piece may be used in the back only, to permit maximum use of the material.

50-GALLON SHAKER

Saves Time and Labor in Mixing Automotive Paints

SPECIAL equipment is being used these days to speed production, lighten tasks, and insure the output of uniform paints for the automotive industry. Two such devices, mechanical shakers for 50-gallon drums and five-gallon cans, were developed especially at the request of the Ford Motor Company.

The idea of churning paint in a 50-gallon drum came shortly after a gallon mechanical shaker was purchased for use in a company laboratory to mix paint samples. Previously, paint stirring was a long and tedious task. Paint was shipped in five-gallon cans and 50-gallon drums equipped with stirrers packed separately. In addition to the labor en-



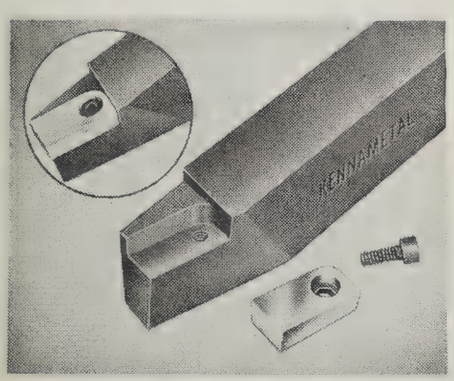
Paint mixer handles 50-gallon drum

tailed, there also was the possibility of paint leakage from the openings through which stirrers were inserted. When the gallon shaker proved feasible, it was decided to try a five-gallon machine. After the larger unit proved successful, a shaker was constructed to handle a 50-gallon drum. By means of this device, a drum of enamel can be mixed in about two hours.

TOOL BLANKS

Are Drilled for Attachment To Steel Shank

A TOOL blank has been developed having a drilled and counterbored hole to provide for attachment to a steel shank by means of a recessed-head cap screw. The angularly-set screw serves merely to hold the tip against the re-



Recessed walls resist thrusts

cess walls, which resist the main cutting thrusts.

These blanks are now available in several of the larger sizes, with formed clearance angles and in all standard grades of Kennametal which is also the name of the manufacturer. Complete tools of various styles—straight edge, lead angle, offset, and so on—can now be furnished with the screwed-on tips. Separate standard blanks will be supplied to those who wish to make their own tools. Blanks of non-standard shapes and sizes having this feature may also be had for special tools, such as are used in shell turning and form cutting of radii and grooves.

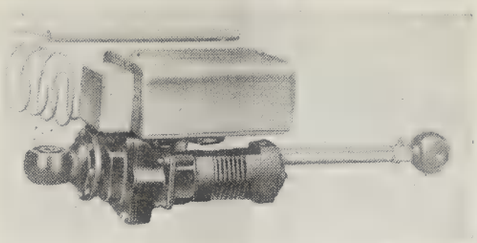
LINEAR ACTUATORS

Light in Weight, Take Little Power

WEIGHING as little as 3.05 pounds, linear actuators have been built to meet the increasing demand of the aviation industry for an efficient method of converting electrical energy into linear actuating force. The design engineer will find them applicable in many places in post-war products.

The Lear Model "400" actuators are made to operate under loads up to 400 pounds of compression or tension. They require low power, 24-28 volts, and have extremely low current drain on the electrical system. In size, the "400" model is less than five inches wide and less than seven inches long, including the limit switch control box and the thermal protector. The extension length ranges from 14⅞ inches to almost 25 inches. These actuators provide a complete package inasmuch as the unit provides the desired moving force without the need of additional accessories.

Exact positioning under all conditions is an outstanding advantage, and



Actuator with temperature control unit

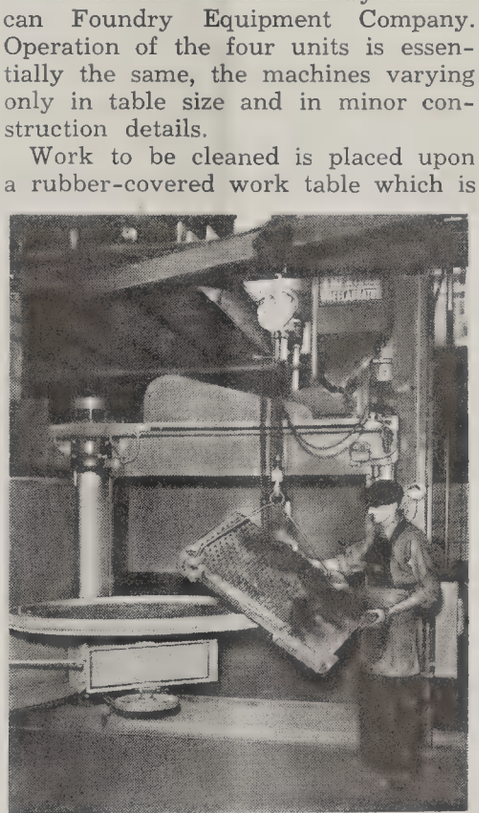
control boxes are equipped with limit switch control of two or three or more positions. Incorporation of the Lear "Fastop" clutch eliminates any overtravel. A movement of a few thousandths of an inch disengages the driven disk of the clutch from the driving disk which is secured to the armature shaft. Gear reduction ratios are available in various combinations. Position-indicating transmitters for visual check are also available.

BLAST CLEANING

Use Extended by Rotary Swing Tables

AIRLESS blast cleaning is being extended to a wide range of intricate or irregular shaped work, formerly cleaned in air-blast rooms, by the use of Wheelabrator Swing Table units manufactured in four sizes by American Foundry Equipment Company. Operation of the four units is essentially the same, the machines varying only in table size and in minor construction details.

Work to be cleaned is placed upon a rubber-covered work table which is



The rotary table carries the work

mounted on the door of the blast cabinet. As the door is closed, the work table swings into the cabinet underneath a Wheelabrator airless blast unit. While in this position the table is rotated at a predetermined speed. The unit whips a continuous stream of abrasive down upon the rotating work to the full width of the table so that

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all surfaces are uniformly blasted to a bright, clean finish. Only a short exposure of the parts to the Wheelabrator unit is required to clean the exposed surfaces thoroughly and uniformly. The unit is then stopped, the door is swung open and the part is turned over for cleaning the underside.

After striking the work, the abrasive falls through perforations in the table top into a hopper below the machine. A screw conveyor transfers the abrasive to the elevator which carries it to an overhead abrasive separator. All broken-down abrasive and useless fines are removed and the usable abrasive falls into a storage hopper for reuse.

PACKAGED COAL

Blocks Made from Waste Will Lessen Fuel Shortage

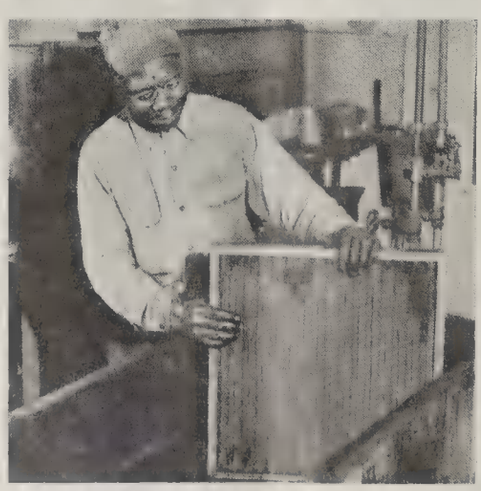
WRAPPED in paper by a new packaging machine as part of a Government sponsored idea to help alleviate the fuel shortage, coal block packages, each weighing 7½ pounds, are made up of hitherto wasted anthracite and bituminous fines. The wrapping machine, made by the Package Machinery Company, turns them out at the rate of 8 to 24 per minute.

The first such machine is already in operation in the Blaw-Knox test plant. Endorsed by the Solid Fuels Administration, the coal blocks, so clean that they can literally be handled with white gloves, will be marketed to householders for furnaces, fire places, cook stoves, and water heaters.

FILTER CLEANER

Diluted with Water, Cleans All Types

DEVELOPMENT of a new process for chemical cleaning of all types of air filters, including air conditioning, engine, marine, and aircraft, has been achieved by Turco Products, Inc. The process eliminates the necessity of using distillate and other materials which leave an offensive odor and are a fire hazard. It also greatly shortens the time required for the complete operation. Under the new process, the filter is removed and immersed for only six minutes in a tank of cold Turco Aktiv, four ounces to a gallon of water. The filter is then removed from the tank and given a cold water hosing to flush away dirt and grease; then dried in a stream of compressed air and dipped into the manufacturer's specified oil. According to time studies, the entire process takes under 13 minutes.



Dipping cleans all air filters

PORTABLE PUMP

Helps to Extinguish Industrial Fires

A NEW light-weight and compact centrifugal pump has many industrial uses including fire fighting and evacuating water from flooded manholes, basements, drainage ditches, and the like. For small factories and mills erected at a distance from city water mains,



Multi-use pump on a trailer

the Rex Speed Prime pump is extremely valuable in the event of fire. Larger plants whose buildings cover considerable areas have mounted these pumps on two-wheel trailers, along with other fire-fighting equipment for speedy towing to the scenes of sudden outbreaks of fire. When used for this purpose, the pumps are altered to accommodate regulation fire hose.

HERMETIC SEALING

Applied to Instruments With Moving Parts

DEVELOPMENT of a method for hermetically sealing electric instruments against humidity, water, dust, fungus, discoloration, and other adverse conditions, was announced recently by engineers of the General Electric Company's meter and instrument laboratory. In tests these instruments have been submerged in 60 feet of water for several days, have been suddenly transferred from a temperature of 67 degrees below zero to one of 185 degrees above, and subjected to dust storms, all without causing any change in their performance.

Experience has shown that in certain climates, especially in the tropics, instruments became corroded, their molded parts swelled and burst, fungus covered the sensitive springs, and, in some cases, the pointers on the instruments fell off. In developing a means for overcoming these conditions, General Electric produced the first hermetical sealing of an instrument containing a moving part.

To obtain a hermetically sealed en-

closure, a thick, strain-free glass window is fused to a metal ring in a glass-to-metal seal. This assembly is then fused to a steel case by a soldered joint. Hermetic sealing of the two terminal studs is obtained by glass-to-metal seals between each metal stud and the metal eyelet. This hermetic assembly is sealed to the steel base by a silver-solder operation.

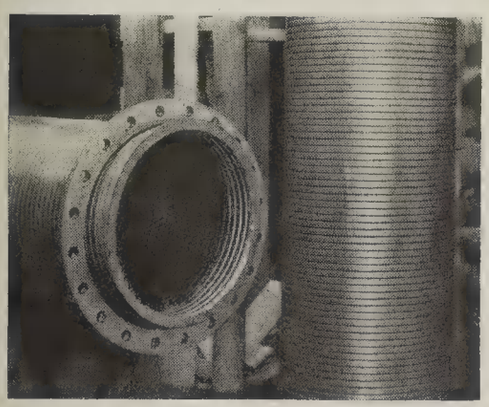
The metal base is secured to the case by means of a synthetic-rubber gasket that is coated with a special sealing compound. The seal is obtained by a crimped-over metal ring, which compresses and retains the gasket.

The glass seal, the soldered joints, and the metal ring form a completely hermetic enclosure for the instrument. According to laboratory tests, this means of sealing is unaffected by thermal shock, mechanical shock, or vibration. The final assembly is evacuated, filled with an inert gas through a seal-off tube located in the base, and is sealed off at a pressure slightly above atmospheric.

METALLIC HOSE

Is Asbestos-Packed For Diesel Exhaust

AN ASBESTOS packed interlocked galvanized steel hose, with an inside diameter of 24 inches, weighs approxi-



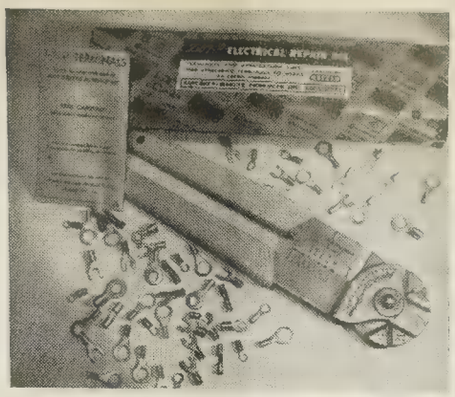
Flexible steel exhaust pipes

mately 70 pounds per foot and is manufactured for use on marine and stationary Diesels as flexible exhaust pipes. Because of its interlocked construction it requires no special tools or heat to bend. This new hose, manufactured by Pennsylvania Flexible Metallic Tubing Company, has a recommended bending radius of approximately seven times its diameter and a working pressure of 15 to 25 pounds per square inch.

WIRING KIT

Provided with Versatile Installation Tool

NOW AVAILABLE to industry for general solderless wiring is a complete electrical wiring kit that includes a six-purpose precision installation tool which cuts and strips the wire, indicates stud sizes, and crimps terminals to the wire. The kit also has an assortment of 100 solderless terminals of the most commonly used types. No soldering is required to make trouble-free



For solderless electric terminals

electrical connections; it is necessary only to insert wire in terminal barrel and crimp with tool. The kit is made by the Aircraft-Marine Products, Inc.

ENGINE DETECTOR

Indicates Impending Trouble in Advance

MULTI-ENGINED airplane pilots can now tell in advance whether they are going to encounter engine trouble, thanks to a new-type instrument developed by research engineers of Consolidated Vultee Aircraft Corporation.

Technically, the instrument is known as an "engine performance indicator." It comprises a rectangular metal box full of electrical equipment, small enough to fit in the side coat pocket of a man's suit. It is installed adjacent to the carburetor of an airplane engine, and its function is to measure the distance (right or left) to which the engine is displaced when the propeller is rotating.

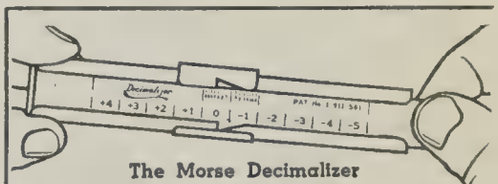
If the engine is functioning normally, the instrument actuates a gage in the pilot's compartment; and this gage shows, with greater accuracy than any similar device previously developed, how much horsepower the engine is putting out. Then, if the engine begins to operate improperly the gage needle oscillates accordingly and a warning light glows on the pilot's instrument panel—giving the pilot plenty of time to cut the engine and feather the propeller.

Previously, because there were no suitable engine warning devices, pilots often could not detect power plant

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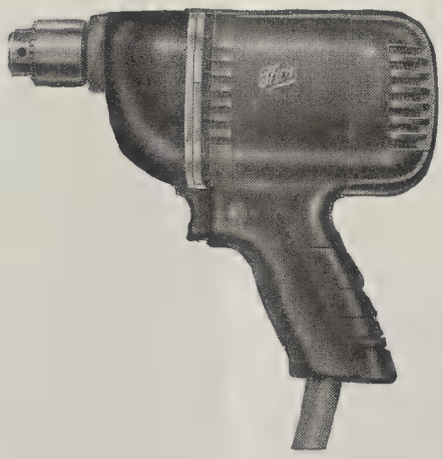
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troubles before an engine actually failed; and then, sometimes, it was too late. Most multi-engined airplanes can fly safely with half of their engines inoperative; but accidents have occurred because the pilots could not detect trouble quickly enough to adjust engine controls and feather propellers. The latter items are important due to the fact that a malfunctioning engine can tear itself to pieces or catch fire, while a "windmilling" propeller will create excessive drag forces and make an airplane difficult to control.

SIDE HANDLE DRILL

Encased in Light and Durable Plastics

A NEW development of Thor plastics encased portable electric drills introduces a side handle type machine which is 20 percent lighter than comparably rated drills with aluminum



Handle position offers advantages

casings, according to the manufacturers, the Independent Pneumatic Tool Company.

The new side handle drills are identical in construction with the original plastics encased pistol grip unit, except for the handle. The gear case, field case, and handle are molded in a specially developed plastics while all internal operating parts are supported in a metal frame entirely separate of the plastics housings—an independent unit so constructed that the tool will operate perfectly with all housings detached.

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By New Method Saves Time and Expense

A SUCCESSFUL method for dimpling high-strength, heat-treated aluminum alloys in all thicknesses up to and including .081 inch has been developed by the Ryan Aeronautical Company. This new method utilizes a tool which fits the standard dimpling machine. The procedure is simple, inexpensive, rapid, and easily taught to the operator. It produces strong, well-formed dimples in high-strength aluminum alloys without radial or circumferential fractures.

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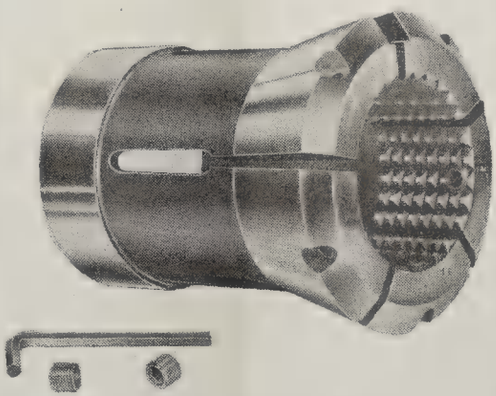
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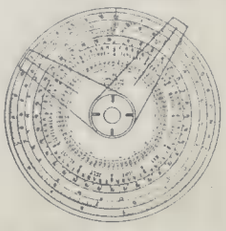
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HOW AND WHY CATHODE RAY TUBES WORK is a 16-page booklet based on the history, mathematical concepts, manufacturing problems, testing, and design of C-R tubes. Complete television set-ups are discussed. *North American Philips Company, Inc., 100 East 42nd Street, New York 17, N. Y. —Gratis.*

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POST-WAR PLANNING FOR INDUSTRY, PART V: SMALL BUSINESS—NOW AND AFTER THE WAR is one of a series of bulletins giving references to, and abstracts of, sources of information on the problems of small business, government aids, and research facilities for small business. *Business Information Bureau, Cleveland Public Library, Cleveland 14, Ohio.—Gratis.*

OPPORTUNITIES IN RADIO AND ELECTRONICS FOR RETURNING SERVICE MEN, by Brigadier General David Sarnoff, is a 28-page booklet designed to aid war veterans in applying their war-time training and experience to development of careers in civilian life. The text covers the entire scope briefly and is supplemented by a complete bibliography of suggested reading. *Radio Corporation of America, 30 Rockefeller Plaza, New York 20, New York.—Gratis.*

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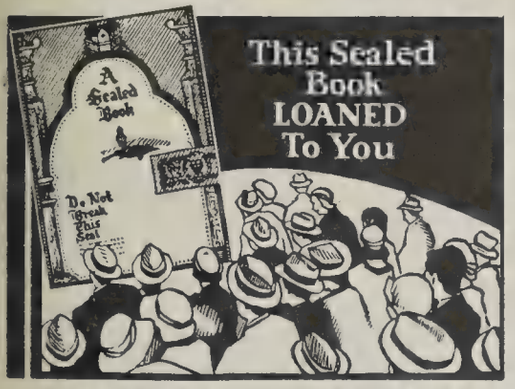
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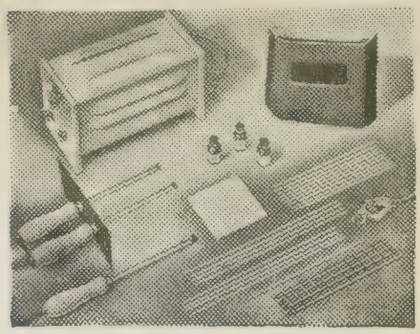
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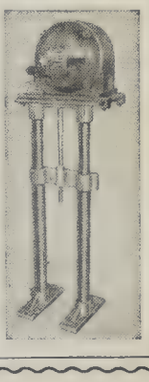
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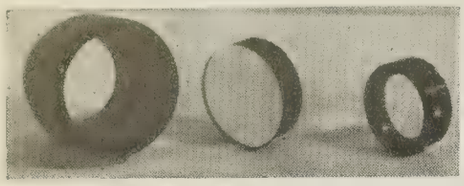
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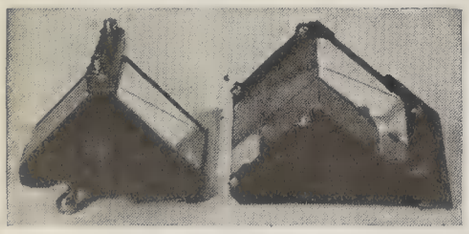
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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN THE fourth edition of "Amateur Telescope Making," in his chapter on the design of mountings for telescopes, Porter wrote (page 142) that he knew of nothing better for a stable polar axis than the crankshaft of an auto engine, together with the engine block itself. Several telescopes have subsequently been made, using such axes.

Before going into Army service, Daniel Langpaap, 200 Kessing Ave., Porterville, California, sent in a description of a 6″ reflector (Figure 1) mounted in that manner. He states that the engine unit cost 75 cents and the whole telescope, including mirror kit and aluminizing of the finished mirror, $16.81.

"The hour circle is graduated on the flywheel, and the declination circle is a protractor. Parts of the starter assembly are used as the slow motion."

Commenting on Figure 1, R. W. Porter says, "I've never seen a mounting that showed so much strength and weakness. If Langpaap would stiffen his slender fork with struts to the flywheel, this would altogether alter its stability." When shown this comment Langpaap replied, "The Army was on my tail and I wanted to get the job done before I was inducted and they didn't leave me time to do that. This is my first telescope, but it isn't going to be my last. I am now in the army (aged 18), so this ends my telescope making for the duration.

"I think," he adds "there is too much warning the beginner about the difficulties of mirror making. My mirror came out an oblate spheroid but figuring this to a paraboloid took only half an hour."

By all odds the most blood-curdling warning to the beginner has been Ellison's paragraph at the opening of Chapter V in "Amateur Telescope Making," where he ominously says: "We now come to the crux of the whole process. Grinding and polishing are purely mechanical processes, which any handy man should be capable of learning in a few lessons. But the man who can produce a perfectly true paraboloidal curve right up to the edge of a mirror is not a mechanic, but an artist; and the artist is born, not made." He continues: "Volumes might be written on the art of figuring and the reader of them would be no nearer being able to produce a true curve after reading them than before, if the talent were not born in him."

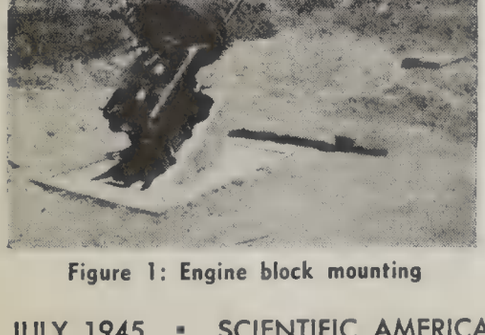


Figure 1: Engine block mounting

Something has now been done about these awesome sentences. From time to time, as stocks of "A.T.M." are sold out, new printings are made and, while a new printing is not a new edition, minor textual changes may be made on these occasions. One change that has just been made for the current fifth printing of the fourth edition is the insertion, on page 95, of the following Editor's Note, directly bearing on Ellison's bogey.

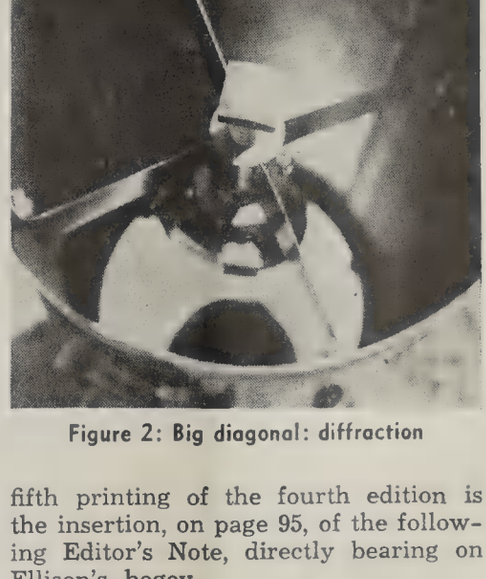


Figure 2: Big diagonal: diffraction

"Many old-timers, advanced amateurs, vividly recalling the misgivings caused when they were novices by the opening paragraph of the above chapter, have urged with feeling that it be struck out of the book. It also must have discouraged many from even starting.

"It is probable that many—perhaps most—novices run away with the belief that a telescope either has a perfect mirror or it will not perform. At the risk of seeming to encourage slovenly standards it ought to be explained by the Society for the Prevention of Cruelty to Beginners that a mirror has to be pretty bad before it won't perform; also that a mediocre mirror will usually seem, at least for some time till your observing acuity has been educated, to be about as nearly perfect as your first grandchild; and that the reasonably good mirror you should aim to make on your first try will probably seem about perfect for a while. Thus Ellison's paragraph misleads beginners by omission.

"Many, before beginning, think of making one telescope and one mirror,



Figure 3: Angel cake catch-pan

which must of course be tops or else, and thereafter using it indefinitely. More common is something like this: On trying out your first mirror you exclaim, 'I did better than I thought I could.' After a few weeks you add, 'but I know its faults and can do better, and while I'm at it I'll make a bigger telescope.' A year or so later you build a third, again larger, and your third mirror will be on nodding terms with Ellison's described ideal. All along, as your observing eye has become more exacting, your manual skill has improved to keep pace. (About this time you go back and, out of curiosity, re-test your first mirrors—the ones you once thought good—and maybe grin a little.)

"As for 'talent,' Ellison doesn't specify how much talent is needed but everybody has talent, which is mainly perspiration. The words 'artist . . . born, not made' have been a real bogey to some, but read Ellison closely; he applies those terms to perfect mirrors alone.

"All sorts of plain average folks, thousands of them, have made successful mirrors, even editors. Cheer up."

Experienced amateurs who recall the howling of the banshee in their dreams after their first reading of Ellison's paragraph, quoted above, may now perhaps feel satisfied that this specter can no longer make the tyro's hair stand on end.

"While home on a furlough," writes another Army man, Pfc. James B. Downs, Jr., 14164282, Co. N, 847th Signal Training Battalion, Camp Crowder, Missouri, "I got into a discussion with an Atlanta amateur telescope maker. As always, the discussion arrived at 'A.T.M.,' 'A.T.M.A.,' and your column 'Telescoptics.' We remembered somewhere you had mentioned that you expected an average of one or two mirrors per copy of 'A.T.M.' Our little club in Atlanta, appropriately called 'The Cloudy Night Observers,' has in its possession copies of 'A.T.M.' and 'A.T.M.A.' that have 13 mirrors to their credit and one in process.

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"The books belong to C. B. Moore, Jr., who broke them in on a 6" *f*/8, a 6" *f*/3.5, and an 8" *f*/10. From him, the books went to D. E. Bowers and myself, where the following were ground: 4" *f*/16, 4" *f*/8, 4" *f*/3.6, 4" *f*/1.5, 6" *f*/2, and an 8" *f*/6.3. [Note wide focal ratio spread of the four 4" mirrors: excellent experience for the worker who would put himself through the mill.—*Ed.*]

"The 6" *f*/2 turned out better than was expected. It necessitated the use of an extremely large diagonal (Figure 2) which cuts its effective light-gathering power very much [and adds to diffraction.—*Ed.*]. Nevertheless, the 12" focal length and 6" diameter is very useful for nebular observing. Some of the very faintest nebulae show up. The power is low but the field is very wide.

"Figure 3 shows the 6" *f*/2 in the pre-polishing stage, using levigated alumina [and, as a most useful catch-pan, an angel cake tin exactly like one your scribe uses.—*Ed.*]. We carried the pre-polishing until the glass



Figure 4: Simple portable mounting

was almost polished before changing to rouge. The total time for rouge and levigated alumina was about two thirds of the time rouge alone would have required.

"It is amazing what a sturdy portable mounting (Figure 4) can be made from some 2 x 2's, 2 x 4's, a dozen nails and a common lawn chair.

"From us 'A.T.M.' and 'A.T.M.A.' next went to C. H. Kitchens and John Brown who built a 6" *f*/3.8, an 8" *f*/9, and a 3" *f*/4.4. The 3" is pocket sized and Brown is carrying it with him in the Army. The books then went to Conrad Meaders, who ground a 6" *f*/8. Then they went to Rolf Sinclair.

"Thus for two books we have 13 completed mirrors and one more in process."

INTERMITTENT mirror makers, who can work a week but then must go away for a month, often return to find their pitch laps in bad shape because of slow flow and filling in of channels. N. J. Siegel, Box 116, Forest Hills, N. Y., obviates this difficulty by suspending the lap, face down, over water in a receptacle. This keeps it moist and cool.

What Siegel actually does is to make the lap on a round metal plate much larger than the mirror, and uses a cardboard collar to confine the melted pitch to the desired diameter. Then, when leaving it for a protracted period, he inverts it over the water, the metal plate tightly sealing the receptacle at the same time. Since the lap is made on the flat backing, rather than the curved one of the usual glass tool, the pitch is thicker at the center. When suspended upside down it therefore tends to flow downward more at the center and this, he says, is easier to cold-press back.

To dispose of the mirror while absent he submerges it, face up, in the same receptacle and marks it "Don't Touch." In some households this is probably sufficient but in others, where the lady with the grim, determined face, the eager eye, and the waving dust mop goes on a tidying-up binge once a week, a burglar-proof safe, large enough to take the whole kit, is recommended. Mysterious "spooks" often scratch mirrors. One such finally proved to be the Everest's cat. Roaming the cellar o' nights it tracked across coarse Carbo on the floor and then tramped over the mirrors left between working sessions.

CARBORUNDUM grains are obtainable two series, the familiar numbered series, like Nos. 80, 120, 220, 400, 600, and a lettered series, F, FF, FFF. Many workers have been puzzled about the reason for the two partly overlapping series and the relation between them. Here is the answer, from the manufacturers.

The approximate numerical grading of the F series is F:280; FF:320; FFF:500.

The numerical powders are more closely graded.

SOME thermal expansion coefficients per degree centigrade.

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Quartz glass	0.00000058
Pyrex	0.0000032
Pyrex telescope disks	0.0000033
200" mirror	0.0000024

IN "A.T.M." are innumberable sidelights that are likely to be missed unless the worker "chinks in" between mirror-making spells by frequent restudy. Here is a case in point, in which a worker had read a certain note but it had not registered in his mind until he happened to read it while he was wrestling with a certain mirror problem on which it bore.

"Not long ago I recall saying 'I wish I could get hold of a mirror with a perfect edge, in order to know exactly what I am supposed to shoot at.' Not long after that my eyes fell on Hindle's paragraph on page 371, 'A.T.M.' For the first time I realized what it meant. Eyes that don't see! Here was the very thing I had been hunting. It took only a few seconds to cut a mask concealing the edge of the mirror, and the diffraction ring which appeared around the inner edge of the mask was evenly illuminated on both sides, just as both edges of Everest's straight-edge ('A.T.M.' page 371) are illuminated. On removing the mask I was able to see that my right edge was brighter than the left, and so my edge was not perfect. I set to work, and finally brought it right. When I had done all that seemed possible, I found that the edge looked the same with the mask as without it."

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*The Tower is an essential part of the voice of radio. Blaw-Knox Towers (some over 1000′ high) are used for broadcasting, communications, navigation, television, facsimile, police work . . . as well as for unclosed electronic purposes.

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REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



America's Frontier — On Wheels . . . See page 65

The Story of HIGHWAY TRANSPORTATION

Anniversary Issue No. 8

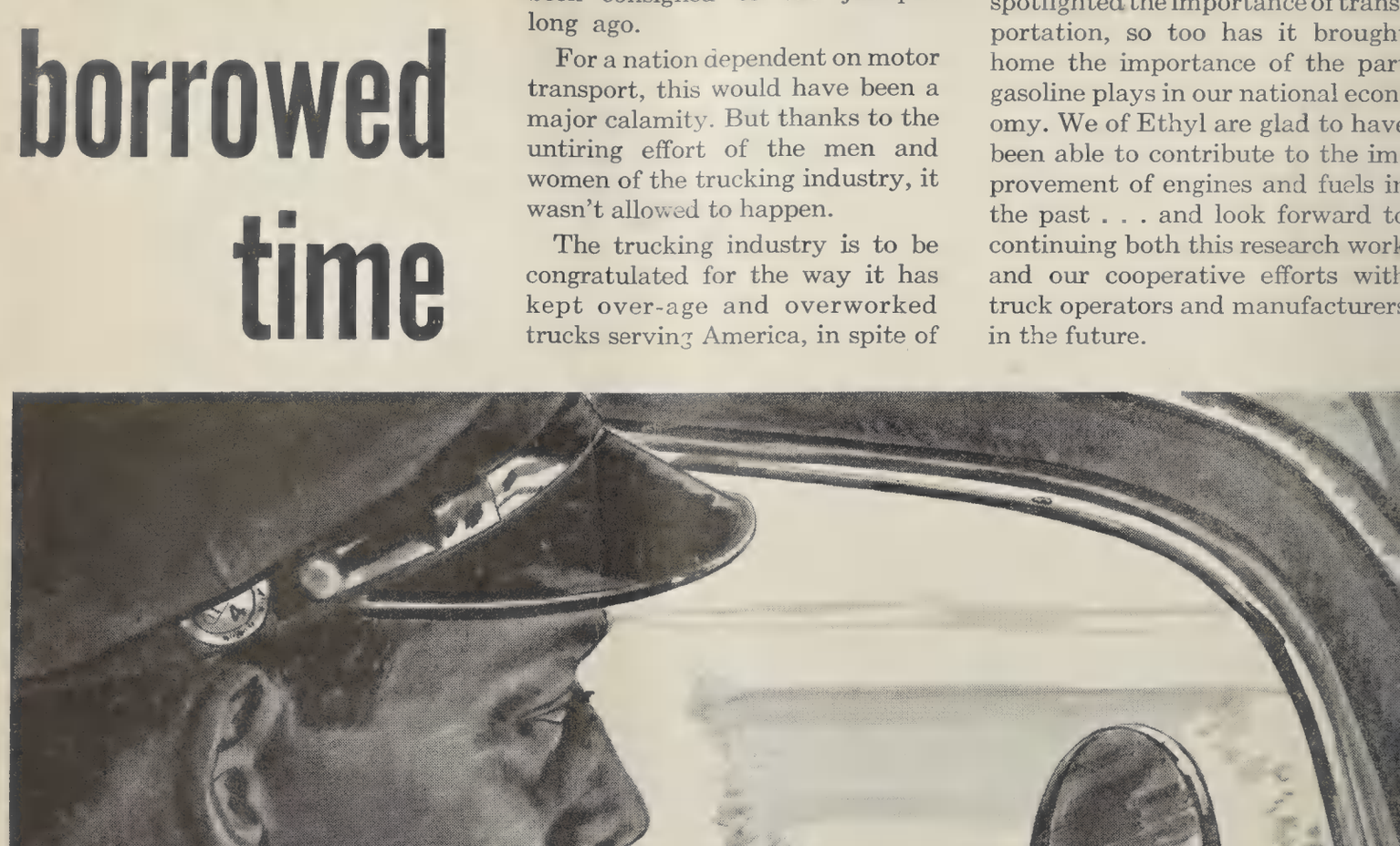
ROLLING ON borrowed time

BY ALL NORMAL STANDARDS, thousands of trucks now carrying war loads would logically have been consigned to the junkpile long ago.

For a nation dependent on motor transport, this would have been a major calamity. But thanks to the untiring effort of the men and women of the trucking industry, it wasn't allowed to happen.

The trucking industry is to be congratulated for the way it has kept over-age and overworked trucks serving America, in spite of limitations on manpower, equipment and gasoline quality.

Just as the war has dramatically spotlighted the importance of transportation, so too has it brought home the importance of the part gasoline plays in our national economy. We of Ethyl are glad to have been able to contribute to the improvement of engines and fuels in the past . . . and look forward to continuing both this research work and our cooperative efforts with truck operators and manufacturers in the future.



ETHYL CORPORATION, *Chrysler Building, New York 17, N. Y.*

Scientific American

—Founded 1845—

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Our Cover: A motorized caravan of flat-bed commercial trucks hauling trailers over the Pennsylvania Turnpike for delivery to war-production centers to relieve a housing shortage.

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Previews of the Industrial Horizon

By A. P. Peck

PATENT LICENSING

OUR DAILY correspondence shows plainly that there are a large number of patent holders who desire to grant licenses under their patents, but who either do not know how to go about finding the right manufacturers or lack the facilities for doing so. Such patent holders will be interested to know that there has been set up in the United States Patent Office a public register of patents available for licensing. No charge is made to the patent owner for recording on this register the fact that he is willing to grant such licenses on stated or reasonable terms.

In the words of Commissioner Conway P. Coe: "Inventors, patent owners, and others desiring information concerning this register should address their inquiries to the Commissioner of Patents, Commerce Building, Washington 25, D. C."

WAR-STYMIED PATENTS

CONSIDER the case of an inventor to whom a patent was issued just prior to Pearl Harbor. Under normal circumstances, his patent would have given him the right to exclude others from making, selling, or using his discovery for a period of 17 years from the date of issuance. However our hypothetical inventor had devised an article which required strategic materials in its manufacture and the Government issued a war-necessitated order which prohibited and still prohibits its production. That was some four years ago. As of the present, almost one quarter of the life of the patent has expired, during which time the inventor, through no fault of his own, has been unable to capitalize upon his ingenuity.

The case is not unique. There are a large number of patent holders whose rewards depend upon the strength of their patent rights and who must reap the harvest during the 17 years of patent protection, or not reap them at all. When the effective life of a patent is cut short by a national emergency, it is only just that relief be granted to the inventor in the form of a patent life extension equal to the period during which he was unable to exploit his invention.

It is gratifying to note that three bills have been introduced in Congress to afford such relief. In essence, any one of these bills, if it becomes law, would provide for the extension of patents whenever the use of them is prevented by war. Copies of this page are being sent to the House and Senate committees to which these bills have been reported, indicating our full approval of patent extension where patent rights have been curtailed because of the war.

The bills referred to are S. 840, H.R. 2043, and H.R. 3069. Readers who wish to obtain further details or to comment upon this legislation are urged to write or wire to Senator Claude Pepper, Chairman of the Senate Committee on Patents, and Representative Frank W. Boykin, Chairman of the House Committee on Patents.

THAT ALL MAY BENEFIT

ON THE industrial horizon looms the biggest composite job that ever faced this or any other nation from the beginnings of time: Conversion from war-production to manufacture for civilian needs and desires; employment for the millions of returning war veterans; maintenance of an economy that has come to be known as "the American way"; and, perhaps most important of all, application to industrial pursuits of the vast technological knowledge acquired during the war.

Appropriate to constructive thinking about these facets of the future are the following statements by outstanding figures in American industry:

"Our problem," says Dr. Gaston Du Bois, senior vice president of Monsanto Chemical Company, "is not merely one of reconversion but also, and quite as important, it consists in the creation of entirely new things, new demands, new activities, which alone can give jobs to an increased number of workers working shorter hours and at higher rates than before the war. . . Technologists realize that such developments require a certain incubation period which, if delayed will delay the creation of new jobs. It should be possible for industry to pilot-plant these new developments now."

Emphasizing that in the post-war period the demands upon research of all kinds—industrial as well as pure science social, and political—will be extremely heavy, P. R. Cassidy executive assistant, The Babcock and Wilcox Company says: "If we do not plan more intelligently for controlling this demand [for material things], than we did after the last war, we shall repeat the rapid inflation and the consequent cycling from inflation to depression. If we concentrate on material things, and pre-war ease and comfort when this war ends, we shall be 'lotus eaters'. . . The war has taught us that when all our citizens concentrate on a common objective and co-operate toward its accomplishment, wonders can be accomplished. If this can be done for the negative purpose of war, it can also be done for positive purposes dealing with the welfare of our people."

"We know that research and invention create new industries and new markets, which in turn generate new auxiliary industries and new jobs," says Dr. Cole Coolidge, assistant chemical director, E. I. du Pont de Nemours and Company. "In 1900 the horse and buggy business gave work to around a million persons. In a typical pre-war year the automobile industry furnished employment, directly and indirectly, to more than six million persons. . . Our high standards of living, and our hope for the future, lie in our *productivity*. That is the key word of our whole industrial mechanism. . . The thousands of people making cellophane, nylon, and neoprene, for example, hold jobs that at the end of the last war did not exist."

IMPROVING ON RESEARCH

WHEN General Electric undertook the job of designing a warmed oxygen mask to protect high-altitude aviators from the dangers of frozen moisture that might clog ports and valves, accepted testing procedure involved human guinea pigs who sat for hours, uncomfortably, in cold rooms. To eliminate this and, at the same time, to maintain better control over the tests, General Electric scientists designed a mechanical head that simulates the thermal properties of the human face and head and which breathes through the nose and mouth.

By such sensible means does technology advance, eliminating variable factors and putting its experiments and tests on ever more sound and reliable bases.

FOR FUTURE REFERENCE

AT Ohio State University is the A. F. Davis Welding Library, one of the most extensive collections on welding in the world; engineers doing original work in welding are invited to send their papers to the Library for use by industry; patent numbers of patents on welding are also desired to complete the file. . . Use of virtually pure oxygen for blast furnace operation may reduce steel mill fuel costs. . . A minor revolution in agriculture is predicted through the design of new plows and cultivators. . . Successful war-time experience with "suggestion boxes" in many industries indicates that this employee co-operation system will be carried over into peace-time and probably expanded.

These scientists are working for you



Worst weather in the world is found atop Mt. Washington, N.H., where ice feathers like these sometimes grow three feet in a single night, and where G-E scientists are conducting cold weather research for the Air Forces. General Electric devices are helping the Signal Corps, the Weather Bureau, and the Air Forces predict the weather all over the world. Accurate weather prediction aids troop movements, saves crops, protects you.

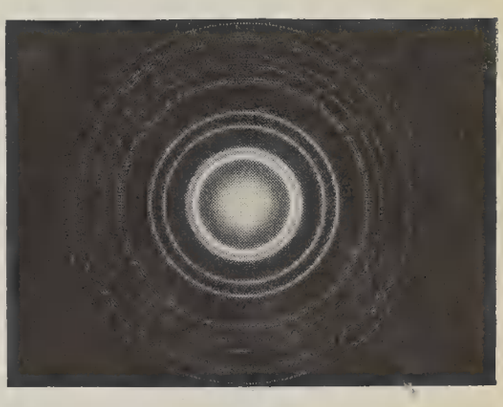
A G-E SCIENTIST, winner of the Nobel prize, studies oil films in a pan of water. And out of this research comes a clue to make glass invisible, to make metals stronger, to create a fog by machine.

Engineers working with certain kinds of radio waves run a temperature. A G-E fever machine utilizes this principle, so doctors can treat patients with artificially created fevers.

This page of pictures isn't one-hundredth part of what is going on at General Electric. But you will see a few ways in which life can be made easier, healthier, and happier. And that's what we are trying to do. *General Electric Company, Schenectady, New York.*



Ever see pure vitamins? These three pinches of vitamin crystals in the hand of a G-E scientist are enough carotene, vitamin C, and thiamin to supply the average man for one day. Research at G-E Consumers Institute helps improve diet, make food taste better.



Electrons took this photo. This picture of gold, made by shooting electrons through a gold sheet less than *one-millionth* of an inch thick, was made in the G-E Research Laboratory, where scientists are studying metals to make new stronger combinations.



You can actually see it grow. New G-E foam plastic grows like magic at the rate of an inch a second from a liquid resembling molasses. When it stops growing, it's ready for use. Lighter for its size than a loaf of bread, it promises to have many uses after the war.

★

Hear the G-E radio programs: *The G-E All-girl Orchestra,* Sunday 10 p. m. EWT, NBC—*The World Today* news, Monday through Friday 6:45 p.m. EWT, CBS—*The G-E House Party,* Monday through Friday 4:00 p. m. EWT, CBS.

FOR VICTORY—BUY AND HOLD WAR BONDS

GENERAL ELECTRIC

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of August, 1895)

MOTOR CARRIAGES — "The carriages driven by petroleum now cost a cent or one and one-half cents an hour per horse power to drive them, so that even for a long journey the cost for fuel is not very great. The first cost of an automobile carriage is about $1,000, not much more than a good carriage. Hardly any one would care to run a machine carriage more than ten hours a day, the cost being 50 cents a day for fuel or $15 per month. Under favorable circumstances a good horse cannot be kept in a large city like New York or Chicago for less than about $30 to $35 per month."

ROADS — "The roads in France and England are almost perfection; but in this country a fairly good road is the exception, i. e., roads that are good the year round. Between the mud of the rainy season and the roughness when this mud is frozen, there are long periods of time when the petroleum carriage would have great difficulty in transporting passengers or freight."

AUTO MANUFACTURE — "In matters of transportation, no question is more generally agitating the public mind than that of horseless vehicles. . . Their construction has reached a stage when it may be well for the carriage and wagon manufacturer to give it consideration. Be made they will, and if carriage builders who are well equiped to produce them continue to antagonize their construction, stock companies, with ample capital, will be formed, and by securing the patents they will control the manufacture and prove formidable competitors."

ARTIFICIAL LIMBS — "The artificial limb manufacturer ranks, in a sense, with the reparative surgeon in the good he does to humanity. Especially at the present day his operations are of importance. . . The leg with restricted back and forward ankle motion was constructed by Mr. A. A. Marks. . . Experience of ten years showed that the ingenious and much praised ankle joint was too weak for hard service, and repairs were very frequently required. . . Now, except in very special cases, the ankle joint is definitely abandoned, and the India rubber foot, the result of a vast number of experiments, is employed."

TIRES — "With a rigid or semi-rigid tire the bicycle rider is obliged to exert sufficient force to lift himself over every obstruction encountered by the wheel; the descent from the obstruction gives back a portion of the power expended in surmounting it, but not all of it. In the case of the pneumatic tire, however, the small obstructions are not an opposing element of any consequence, as the tire yields, in lieu of the wheel being raised, and the result is the wheel travels as upon a smooth track."

REHEATING STEEL — "The Carnegie Steel Company at Homestead tested July 17 a new plan which Manager Schwab and Chief Electrician Kinkey have devised for reheating molten metal that has become chilled before it can be poured into the moulds. The new plan consists in using an electric current, by which an intense heat is generated. The molten steel was set to bubbling, and the light and heat were so intense that the workmen's eyes suffered seriously, but at the next test they will wear glasses."

METEOROLOGY — "Meteorological data will be a necessary to the engineers of flying machines, when practically perfected, as charts are to sailors. Ballooning can be then carried on with much less risk than at present, since it will be an easy matter to determine what currents of air are likely to be met at various heights, just as it is now a small task to find the Gulf Stream or the trade winds. A still greater service will be rendered by this information to scientists, who now believe that men will be able to soar like birds as soon as the upper air currents are definitely understood."

TELEGRAPHY — "By the connection of several different lines telegraphic communication was established between Derby and Cape York, Australia, a distance by the wires of 7,246 miles. This is believed to be the longest telegraph line in the world. The rate of transmission was eleven words per minute. There were fourteen repeating stations."

CABLE'S END — "A few days more will witness the ending of the cable system as a means of passenger transportation in Philadelphia. Within a week every remaining cable car on the Market Street main line, the last link in the cable system, will be displaced by trolleys."

ELECTRIC LOCOMOTIVE — "With the view, principally, of escaping the nuisance of smoke and gases from a steam locomotive in drawing passenger trains through a long tunnel, the Baltimore & Ohio Railroad, with the co-operation of the General Electric Company, has brought into its service a powerful electric engine. . . The machine bears with its entire weight of 96 tons, or 192,000 pounds, on its eight driving wheels, which is considerably more than twice the weight on

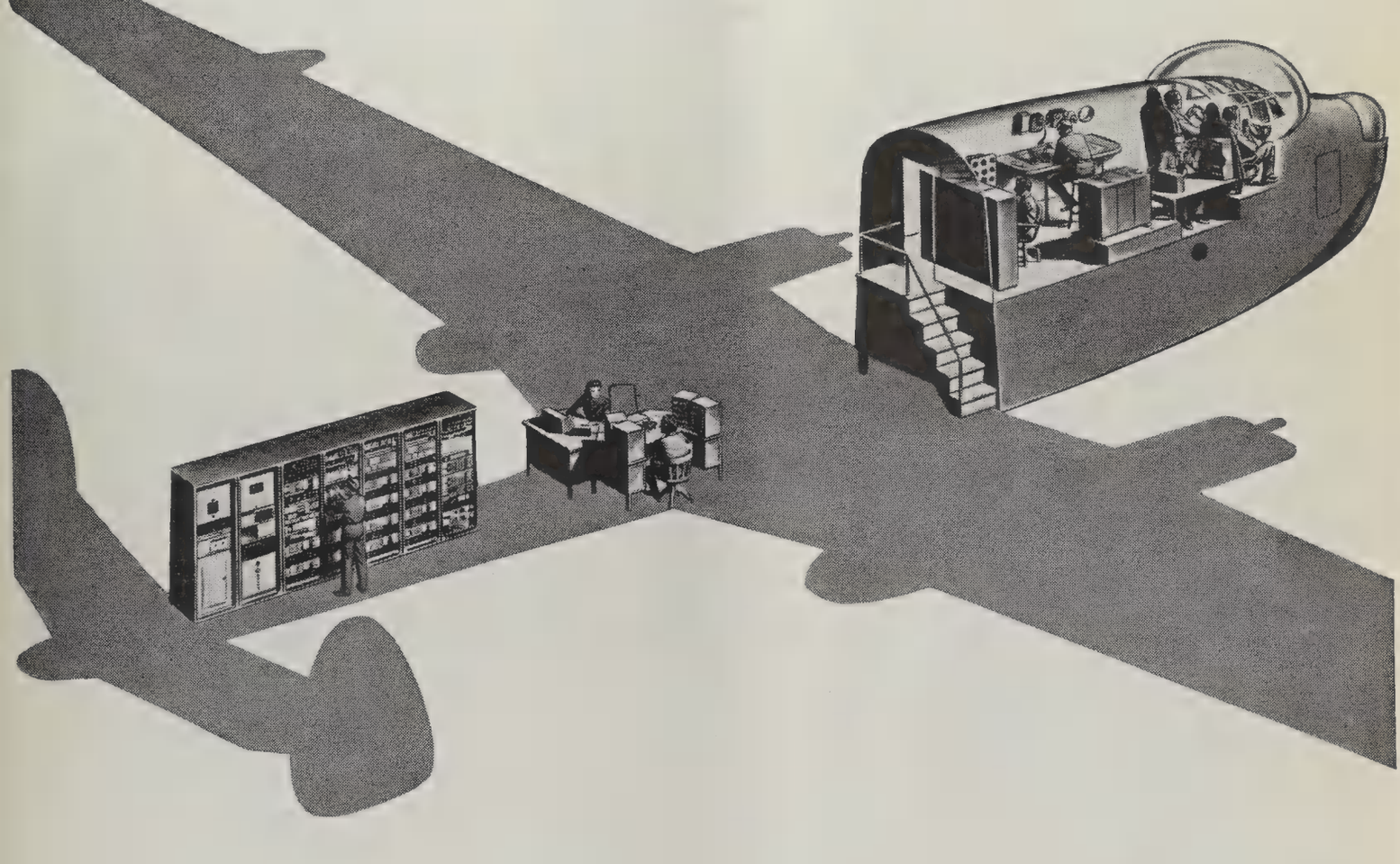


the driving wheels of the heaviest steam locomotive. It has two trucks and eight driving wheels of a diameter of 62 inches each outside of the tires, the wheel base of each truck being 6 feet 10 inches; the length over all, 35 feet; and the height to top of cab, 14 feet 3 inches. . . There are four motors, two to each truck, or one to each axle. . . Each motor is rated at 360 horsepower and takes a normal current of 900 amperes at a pressure of 700 volts. The controlling devices and measuring instruments occupy the interior of the cab, the controller being of the series parallel type."

LEVEES — "Captain George McC. Derby has announced that the attempted feat of building a levee with the force pumps on the great dredge, the Ram, was successful. . . The Ram is very powerful; in practice it was found that she could deliver about 2,000 yards per working day of ten hours. The total cost per cubic yard of a levee built by the Ram to a height of 10 feet will be 3.91 cents per yard. Hitherto the price of levee work has ranged from 10 to 12½ cents on an average per cubic yard."

STREAMLINING — "A novel method of determining the curves of least resistance in water and air was recently employed at Newport News. The idea was to make the water and air themselves shape the model, and accordingly rectangular blocks of ice were towed in the water, and the alterations in their shape and in the pull necessary to keep them moving at a certain speed carefully noted. . . Wax was the material used for the models moving in air, and the air currents were heated sufficiently to gradually melt the wax."

THIS SEA-GULL LIVES ON THE GROUND



This is a "flight trainer"— an electronically operated replica of the PBM-3 flying boat. It was conceived by the Bureau of Aeronautics and developed by Bell Telephone Laboratories to train Navy bomber crews on the ground.

The new crew climb a few steps to get in and from then on it is like being in a big plane at night. Controls tug against the pilot's grasp and "engines" roar in response to the throttle. From his desk, the instructor creates every situation of real flight — even to iced-up wings, conked-out engines and sudden air-pockets. The novice pilot and his crew get the feel of danger without the hazard.

Once the control dials are set, the various effects are automatically organized and set in motion by concealed machinery which includes 200 vacuum tubes, 60 motors, loudspeakers and hundreds of associated parts. Twenty Laboratories engineers worked more than a year developing the project. Drawings covered an area equal to 15,000 square feet.

This is only one of the 1200 projects in which our experience has been able to help the Armed Forces. What we have learned in devising electronic circuits to train flyers will help build better telephones.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for the Armed Forces at war and for continued economies and improvements in telephone service.

POINTED RHYMES FOR TRYING TIMES

by
Berton Braley

Here is wisdom by the peck
Versified to save your neck!



DON'T BLOW IT

Oh, workman or scholar,
Hang on to your dollar
And do not spend it soon,
For every cent
Unwisely spent
Inflates the price balloon.



IT MAKES SCENTS

To market (black market) to spend lots of jack
Careless of how many ceilings you crack,
To market (black market) where prices are dear,
—Gosh, there's a terrible smell around here.



If you can keep your head and calmly ponder
How silly spending drives the prices high;
If you can save the cash you'd like to squander
And only buy the things you need to buy;
If you can do your part to fight inflation
By simply being thrifty with your pelf,
You'll do a vital service to the nation
And—furthermore—you'll benefit yourself.

Bonds you buy with payroll earnings,
Help fulfill your future yearnings.

NO GAMBLE

When the war is over, will the prices
rise or fall?
We do not know the answer, and
nobody does, at all.
But this much we *can* prophesy—
whichever way they go:
You will find it more convenient if
you've saved a little dough.

★ ★ ★



Money in your pocket,
Take it out and sock it
Into War Bonds, which
Help to make you rich.

DOUBLE AND NO QUITS

When you boost your paycheck quota and allot it
To another bond—it's pretty soft for you!
For, although you've spent your money—you
have got it,
And the Interest is interesting too.



WHO? ME?

There was a little dope with a fat
pay envelope
And she spent every cent that
was in it.
And she wondered, by-and-by,
why the prices rose so high,
But she didn't blame herself for
a minute.

★ ★ ★

INFLATIONARY MARY

Inflationary Mary spills
This silly kind of chatter:
"My little teeny-wee bills
And spendings do not matter.

"And if I cheat a little bit
On rationing and ceilings
The Nation's welfare isn't hit
By my small lawless dealings!"

Inflationary Mary's wrong.
For she'd be much to blame
If people in a mighty throng
Should say and do the same.

Small spendings, in the aggregate,
Reach sums extraordinary,
So let's not try to imitate
Inflationary Mary.

★ ★ ★



SNAKE IN THE GAS

There was a crooked man and he
lived in crooked style,
He dealt at crooked markets with a
smugly crooked smile.
He viewed himself as clever with
his crooked ration book,
But everybody knew him for a
crooked little crook.

★ ★ ★

THE GANG'S ALL HERE

You may ask, "Why should *my* spending
Cause inflationary trending
Though I squander every penny I have got?"
—If you're joined by sixty millions
Of civilians blowing billions,
You'll discover that it matters quite a lot!



YOU CAN LAY TO THAT

As the best egg for a nest-egg
Buy a War Bond—buy a batch.
But you gotta keep 'em settin'
Or they ain'ta gonta hatch!

Save your pay
Here's a way—
Bonds and savings and insurance
Give your future more endurance.
Mrs., Mister,
Brother, Sister,
Don't compete in buying things
That is whence inflation springs.



ONE PERSON CAN START IT!

You give inflation a boost

—when you buy anything you can do without
—when you buy above ceiling or without
giving up stamps (Black Market!)
—when you ask more money for your services
or the goods you sell.

SAVE YOUR MONEY. Buy and hold all the War Bonds you can afford—to pay for the war and protect your own future. Keep up your insurance.

A United States War [illegible] prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in cooperation with the Magazine Publishers of America.

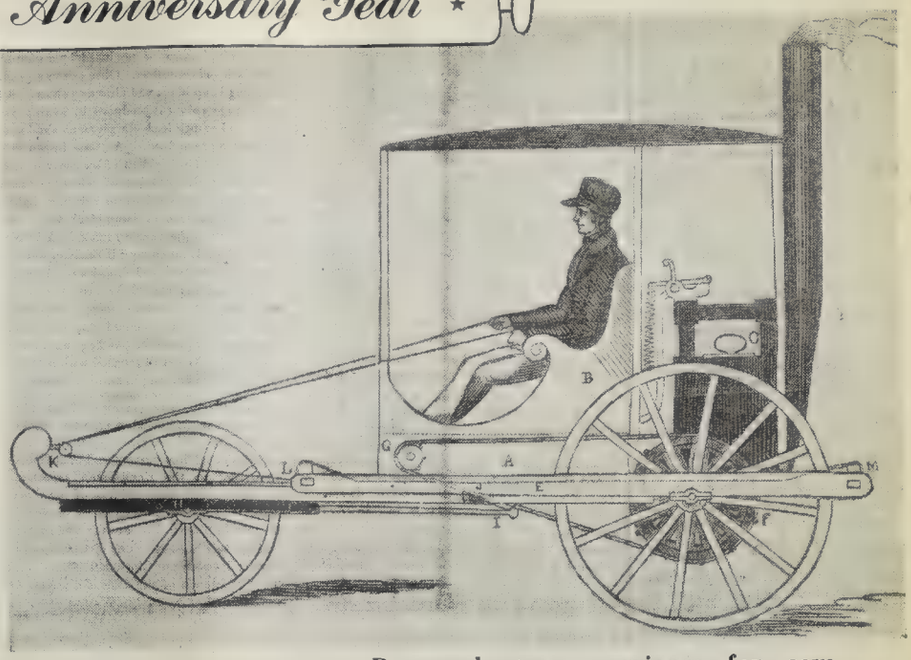
Scientific American

AUGUST • 1945

★ *100th Anniversary Year* ★



Virot's steam carriage (France, 1888)



Proposed steam carriages for common roads (United States, 1845)





Above: French steam tricycle and trailer (1888)

Right: Simonds' light steam road wagon (1894)

Illustrations above are from Scientific American. Dates indicate year of first publication

America On Wheels

By LESLIE PEAT

From Evans' Road Vehicle of 1789, Through the Famous Selden Patent of 1895 and the Rough-and-Tumble Days of the Early 1900's, to the Present Day, Automotive History in the United States Shows a Dominating Influence on the Growth of Other Industries. Co-Operative Engineering, Imperative to the War Effort, Will Benefit Many in the Future

SCORES of competent engineers are hard at work today trying to harness jet propulsion to highway transportation for tomorrow's tomorrow. Thus the pioneering spirit of mankind which from time untold has been seeking to eradicate distance and reduce time is still hard at work. But research these days is correlated, and with the aid of organized facilities, instead of the handicaps of unrelated experimentation which

TRENDS OF 1902

Of 23 cars, 18 had engines under the seat or in the rear, and only five had them under the hood.

Of 20 vehicles, 14 were battery-equipped; 14 had some form of planetary transmission, five had sliding pinion transmissions, and one had friction disks.

Sixteen out of 32 had two speeds forward and six boasted three, 17 had chain drive, five used bevel gears, and one had spur gear drive.

The average speed of a group of 26 vehicles was 20 miles an hour; average cost in the light-weight field was $896 and $1585 for the heavier vehicles. In the light-weight group the engines averaged six horsepower.

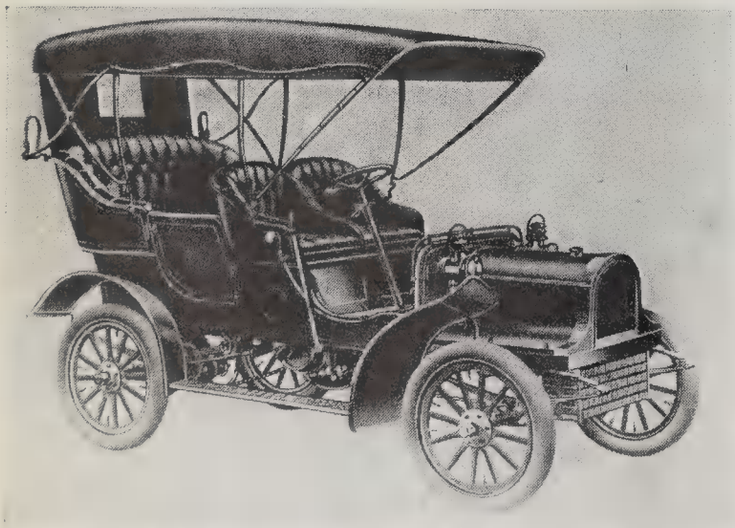
Most had tiller steering, and Packard advertised an ammonia gun to squirt at dogs with a penchant for running alongside and nipping at the tires.

marked automotive developments before the turn of the present century, the future of technological advance is a bright one.

While the chronology of automotive developments stems from hazy, almost legendary, writings, the real beginnings may be said to lie in a patent granted to Oliver Evans for a self-propelled road vehicle in 1789 and in Robert William Thompson's British patent on a pneumatic tire 100 years ago. Many steam, electric, treadle-operated, and other types of vehicles have appeared since. An engine using gunpowder for fuel was made to operate—but it was too dangerous to become popular. The track-layer, or Caterpillar type of tractor, made its bow 99 years ago.

No one person or single corporate group can be credited with the development of the automobile as it is known today. It has been a gradual process with many persons in different countries sharing in the research that was destined to bring about the epoch on wheels of the 20th Century. Although France led in initiating tests and experiments in the earlier days, America was from the first the leader in production.

The industry got a healthy start in this country about 1900 with production during that year of around 4000 cars, and with managerial and organization talent quickly gravitating to this new and promising enterprise from many long established industries. American automobile builders contributed many improvements, but the two most important aspects of the industry which developed here in the early part of the century were mass production, based on the assembly-line principle, and the standardization of parts.



David D. Buick's 1904 model, the first Buick to go on the market. It sold for $850, top and lights $125 extra. Buick formed a company with $75,000 capitalization in 1903 and had sold 750 cars by the end of the next year. In 1906 the company brought out a four-cylinder car with sliding gear transmission. General Motors Corporation bought the company in 1908

The period from 1900 to 1910 saw the industry out of the workshop stage—often in smithies—and into an important branch of American manufacturing, while the next five years witnessed the adaptation of its products to the middle-class market. During both of these eras there was a remarkable growth interrupted only by recessions corresponding roughly with changes in general business conditions.

Output in 1903 stood at 11,235 units; by 1910 it had jumped to 187,000, and five years later to 970,000. After 1917, the expansion was marked by five major factors: The self starter; the cord tire; low-priced cars; instalment sales; and closed cars.

A recent study of a representative group of 1940 passenger cars showed that the average retail price was about 23 cents a pound and $9.00 per horsepower, as compared with about 32 cents a pound and $16.70 per horsepower as of 1929. The price of the post-war car and truck will depend, of course, largely upon wage rates and materials costs, with the latter weighted heavily by the former.

IMAGINATION — The development of the mechanics of modern highway transportation owes much to the older American manufacturing industries, and many of the manufacturing executives got their start in railroad shops, at tool makers' benches, in bicycle plants, and in other factories which were long established when the first wheezing motor car passed them on a dusty street and fired their imaginations with the possibilities of the coming horseless-carriage era.

Many interesting related factors reflect the influence of the internal-combustion engine on our way of life.



Mack's first bus, 1900, was bought by a sight-seeing company. Builders of many commercial vehicles, Mack also builds marine and automotive Diesels

It has opened up isolated country districts; motor vehicles stimulated to a remarkable degree the development of the country and its subsequent industrialization. America had no national or even state road policy at the beginning of the century. All the hard-surface roads in the country at that time would scarcely have formed a highway from New York to Boston if laid end to end. None of it could be called "good roads" today.

But, roads or no roads, the motor car was being developed in the United States at the turn of the century; when it was accepted by the public as a useful vehicle, motorists demanded better roads. The American Automobile Association held its first good roads convention



More than 100,000 automotive service establishments in the United States, doing a pre-war annual business of about a half-billion dollars, have replaced the village smithy as repair shops. Several automobile companies started from blacksmith and wagon shops

in 1907—meeting jointly with the National Grange—to discuss methods by which roads could be developed, but it was not until 1916 that Congress passed the Federal Aid Road Act.

BETTER ROADS — Thereafter the country began to build good roads with extraordinary speed. Federal expenditures for roads jumped from 63 million dollars in 1921 to 1171 million dollars in 1939. After the war the nation's roads will be modernized still further if Congress has its way. Tentative plans call for the expenditure of 1500 million dollars for a three year building and improvement program with the individual states and Federal Government matching the outlay dollar for dollar.

As the automobile revolutionized the living and thinking of people, it was an equally dominating force in the growth of other industries. When World War II broke out in Europe the motor industry was using a preponderant share of many raw materials: 51 percent of malleable iron, 75 percent of plate glass, 68 percent of upholstery leather, and 80 percent of rubber. In addition, the automobile took more than 18 percent of the steel output, approximately 10 percent of aluminum, some 13 percent of copper, and about 34 percent of lead.

The sturdiest link in the industrial entity built up by the motor vehicle is the oil industry. In its early days gasoline, representing only a fraction of petroleum, was considered undesirable and refiners were sometimes prosecuted for dumping the stuff into rivers and streams.

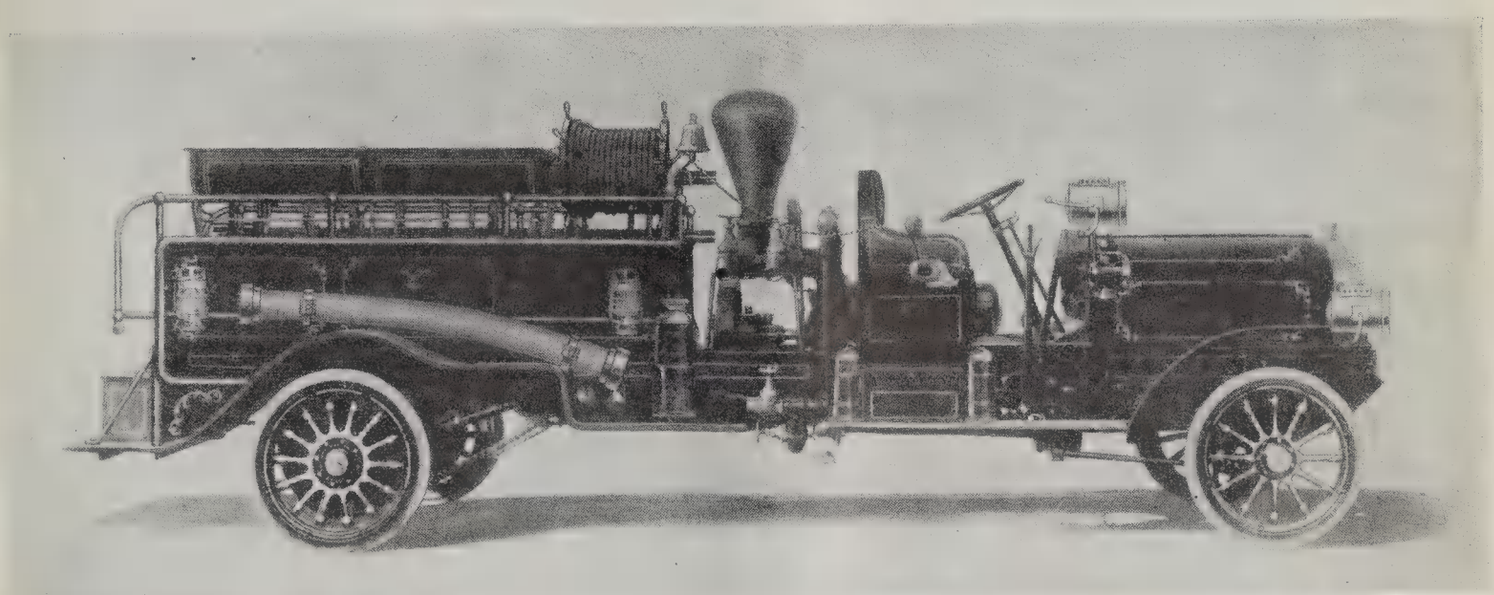
Statistically, the oil industry was born when the internal-combustion engine was mounted successfully on wheels. Production of crude oil soared from 63.6 million barrels in 1900 to 1500 million barrels two years ago.

Just as the motor vehicle industry grew from infancy prior to World War I to one of the nation's staunchest economic factors, it may be expected that the engineering, sales, and management programs of the automobile and truck business will accelerate to new levels as soon as the war manufacturing job is ended. Whatever the compromises between comfort and style on the one hand and economy on the other may be in respect to passenger cars, the factors of durability and economy of operation will determine the success or the failure of truck manufacturers.

DURABILITY — Improving durability has been a 20-year achievement of the truck and bus manufacturers, and their service experience with current military vehicles is a substantial asset in continuing this trend. Truck owners consider they are due about 50,000 miles of mechanical-trouble-free operation, whereas they individually accept the usual 4000-mile guarantee on their own passenger cars. This dependability of American trucks and buses is a complicated story of careful development of materials, manufacturing methods, and detail design over a period of a quarter of a century.

It is safe to say that the design and manufacture of heavy-duty trucks and large buses have contributed more to the progress of metallurgy during the past two decades than any other product. Many of the metallurgical and lubricant developments which have made for better passenger cars have stemmed from the work and experience on these vehicles, where performance requirements were more rigid.

Gear steels of greater strength and longer fatigue life; other new steels which have multiplied by many times the life of springs; alloy irons for castings, less subject to wear and abrasion; extremely hard materials for valve seats which, together with valve steel developments, increased valve life from a few thousand miles to virtually the life of the truck, are a few ex-



Starting the retirement of horse-drawn fire engines, Mack built the first motorized hook and ladder fire truck in 1910 and this pumper in 1911. Mack is expected to be an important factor in the fire-fighting equipment field post-war



Founder of the Autocar Company, Lewis S. Clark's vision led him to experiment with automotive vehicles in 1897. The tricycle with which he is shown here (but which never went into production) had a single-cylinder engine and weighed about the same as a front spring of a 1944 heavy-duty Autocar truck

amples of metallurgical developments traceable to the constant effort to increase the life of the motor truck.

Virtual abandonment of the four-cylinder engine for the six-cylinder power plant enabled operation at higher speeds with greatly reduced destructive vibration. With the six-cylinder engine came a larger number of bearings for crankshafts and force-feed lubrication, which permitted carrying heavier loads at higher speeds with a longer life than was possible with the previous four-cylinder designs.

To eliminate destructive "whip" in the longer crankshafts of the six-cylinder engines, engineers developed torsional dampers which, when mounted on the front end of the crankshaft, resulted in increasing crankshaft life from an average of 35,000 miles a few years ago, to a point where a crankshaft today lasts almost indefinitely.

Higher operating speeds of both trucks and engines and higher output of engines were, of course, reflected in increased operating temperature throughout the engine. Since engineers could not limit the expansion of metal under heat, they set to work to make the expansion uniform and thus prevent engine distortion.

START AND STOP — In the fields of transmission and brake development, many automotive engineers believe they have a long way to go, although the newer types of transmissions offered with late model cars, trucks, and buses just before the war were a step in this direction. Despite the lower efficiency of hydraulic couplings, torque converters, and mechanical automatic transmissions, engineers are agreed that improvements are demanded because of the ease of operating heavy vehicles with these aids. Hence many development projects are afoot in this area of automotive engineering.

Brakes face radical improvements. Overloading is a common practice, and the necessity of carrying off the heat generated had become acute before the war. Many truck engineers are looking into aircraft brake systems for an answer, and a large number of projects on brake design and test work are underway throughout the industry. During the past two decades life between brake re-linings has been more than quadrupled, thanks largely to the developments of hydraulic and pneumatic systems and improvements in metallurgy and brake-lining materials.

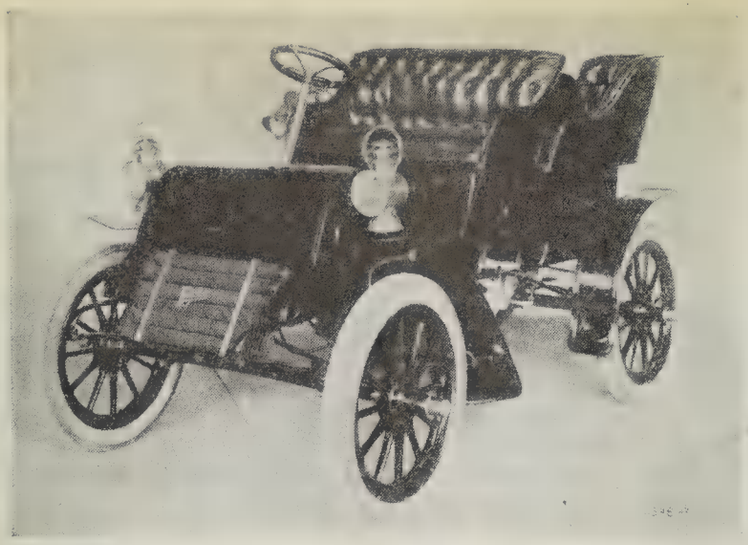
FIRSTS — Probably in no industry has the "battle of the firsts" been waged with more words and engendered more bitter and frequent recriminations than in the automobile business. Most famous in the chronicle was the long-fought Selden patent case which stemmed from the experimental work of George B. Selden, a graduate of Sheffield Scientific School, Yale. In 1877 he started to work on a "road engine," and in 1879 filed a patent application on the basis of drawings and descriptions. A patent attorney, he succeeded in keeping his patent from being granted for 16 years. Thus in 1895 he received a patent (U. S. No. 549,160) for an invention of 1879, but had not yet built a motor car.

Then, in 1898, Selden assigned his patent to the Electric Vehicle Company. In 1900 the company sued the Winton Motor Carriage Company for infringement, notice having been served upon the infant industry that stormy litigation was ahead. The Winton company and 17 other manufacturers joined with the Electric Vehicle Company and formed the Association of Licensed Automobile Manufacturers which, by July 2, 1904, had 33 members. Names such as Olds, Autocar, Packard, International, Cadillac, Studebaker, and Buick were on the ALAM roster, as were important pioneering corporations which have ceased to exist or been merged with present manufacturers; Apperson, Knox, Locomobile, Hayes-Apperson, Peerless, Franklin, Thomas, and Pope, were among these.

Conspicuous by its absence was the Ford Motor Company, and for the eight years of the ALAM's existence Henry Ford fought—often alone—against the 1¼ percent royalty of the retail price which each member manufacturer paid the association. The American Motor Car Manufacturers Association was formed by those who, like Ford, did not agree with the famed decision of September, 1909, handed down by Federal Court Judge Hough upholding the Selden claims. By the end of 1910 Ford and Thomas B. Jeffery stood out alone.



Most venerable of today's automobile is the Oldsmobile, which made its bow in 1897 with this single-cylinder model. A contemporary advertisement claimed a speed of 20 miles an hour on a smooth road. General Motors acquired Oldsmobile in 1908



The Cadillac, which first appeared in 1902, was a product of Leland and Falconer, machinery builders. Powered by a single-cylinder engine with a five-inch bore and a five-inch stroke, this vehicle had ball-bearing axles and a planetary transmission. An important feature was a "novel sparkplug which could be removed for cleaning with the greatest of facility"

Although in 1907 the royalties were reduced to 4/5 percent, it has been estimated that the growing industry paid a total of $5,800,000 in royalties. The ALAM was disbanded after the Circuit Court of Appeals held that the Ford Motor Company had not infringed the Selden patent. The ALAM's membership formed the Automobile Board of Trade, which soon became known as the National Automobile Chamber of Commerce, now the Automobile Manufacturers Association, the trade association of the vehicle manufacturers.

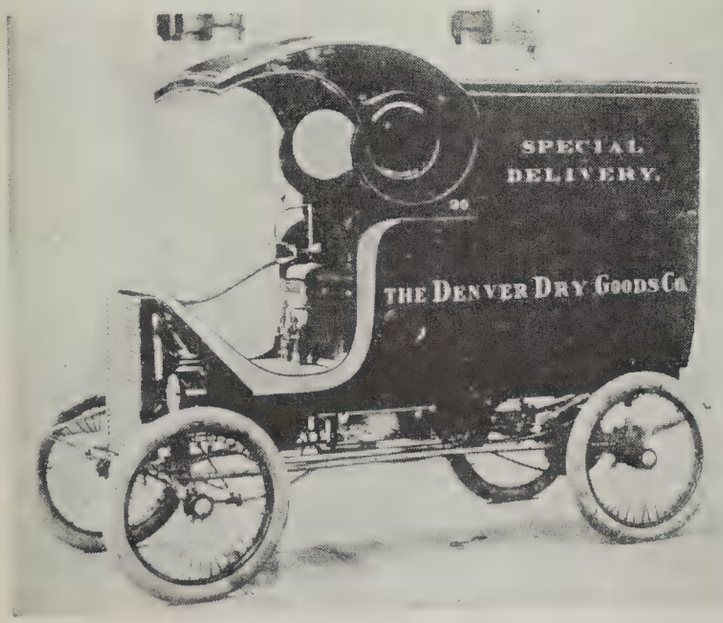
In view of the circumstances just related, any resume of "firsts" in automotive inventions and developments must be done with a sketchiness which is necessitated by the cloudiness of the industry's history.

By the turn of the century, the horseless carriage had become a fact and the automobile began to take on the semblance of a utilitarian vehicle rather than the fad it had been. Eight thousand vehicles were in use. These companies, still in business, were in production: Autocar, International, White, and Mack (now trucks exclusively), Oldsmobile, and Packard. Scores of other famous names, since out of production, contributed to 1900's 4192 automobile production.

By the end of the next ten years, 522,497 cars and 70,228 trucks, with a wholesale value of 385½ million dollars, had been produced. Among the mechanical improvements were the introduction of steering wheels to replace the tiller in 1900, and automatic spark advance in 1901—both by Packard; steering knuckle by Elliott; shock absorber by E. V. Hartford; speedometer by J. W. Jones; Prest-O-Lite for headlamps by Eugene Bournonville; demountable rims; lamps included as standard equipment by Pope-Hartford in 1904; tubular horns by Miller Reese Hutchison; tire chains by Weed; power tire pumps; ignition locks; storage battery as standard equipment introduced by Buick; front bumpers; nickel-plated trim by Oldsmobile; Buick's sliding gear transmission in 1907; vanadium steel introduced by Harold Wills of Ford; sleeve valve engines; left-hand steering; silent timing-gear chains; electric horns; baked enamel finish; helical gears; Hupmobile's transmission and clutch integral with the engine; multiple disk clutches; one-man tops; overdrive transmission on Gramm trucks; and Buick's six in 1910. More than 125,000 automotive inventions had been patented by the end of 1910, and nearly 200 passenger car and truck manufacturers were in the business at the end of that decade.

Automotive standardization was begun in earnest in 1910 when the six-year-old Society of Automotive Engineers named Major Henry Strouther as chairman of its Standards Committee, and 13 divisions and their subcommittees went into action on scores of projects.

NAMES — Motor vehicle licensing legislation, installment selling of cars and trucks, an attempt to regulate used car prices, and cross-country races were some of the highlights of that historical era during which Ford became one of the industry's most important names and hundreds of companies ventured into the vehicle manufacturing arena. These were rough-and-tumble days, in corporate financing and in vehicle sales schemes, as well as in engineering. The decade from 1900 to 1910 saw the beginnings of names now famous the world over, such as Buick, Hudson, Cadillac, FWD, Studebaker (first with an electric and then in 1904 with a





When Thomas H. White started to manufacture sewing machines some 86 years ago, he laid the foundations for one of the most successful automotive vehicle businesses. The famous White Steamer stemmed from the invention, by his son Rollin, of the automobile flash boiler in 1899. Above is the White steam car and at left the steam truck, of 1900. In 1909 the company turned to gasoline engines exclusively



Packard's 1902 "Old Pacific," with the late Tom Fetch at the wheel, made a transcontinental trip in 1903 and blazed the trail for the Lincoln Highway. This feat—and track racing—was the era's most dramatic sales promotion for the horseless carriage. Formed in 1900 by an electrical equipment manufacturer of Warren, Ohio, Packard Motor Car Company was credited with many "firsts" during the initial decade of the present century. First Packard that was offered for sale was purchased by Wm. Rockefeller

gasoline vehicle), Mack's first bus, Graham, Overland —and, in 1908, the Willys-Overland—Reo, International Harvester Company, Diamond T, Packard's first truck, Pontiac, Oakland, Autocar trucks, Hupp, Chevrolet, Lincoln, American-LaFrance, and Federal. More than 350 other names, lost by merger or because of withdrawal from business, were on the roster of "those present" during that period. Altogether, there have been more than 1500 makes of cars and trucks on the market, all built in the United States.

The pattern of mass production was beginning. Always dependent upon the products of supplier companies, the growth of vehicle demand nurtured many metal-working companies and established new ones as production figures soared and as new mechanisms were developed. Despite advanced engineering of European manufacturers, American mass production methods started a trickle of United States cars and trucks overseas until, in 1943, total United States automotive exports reached nearly 368 million dollars. These often sold despite a substantial disadvantage because of heavy import duties abroad.

Many American cities tried to legislate the automobile off their streets in the early days. Due to the vigilance of the motorist, most of these regulatory attempts were blocked. It is recorded that the city fathers of Glencoe, Illinois, used tax-payers' money to build humps across the streets to discourage driving. Speeds were held down. Sale of gasoline for vehicles was forbidden in some places, although explosive cleaning fluids were under no ban. Several states passed laws requiring a licensed steam engineer to drive a steam car, and a number of statutes were proposed to make the same requirement for operators of gasoline vehicles.

TRENDS — Automotive mechanical development can best be viewed in four periods: From 1900 to the beginning of World War I; World War I itself; from the Armistice to the beginning of World War II, and during the emergency engineering achievements of World War II to date. Here are four reference points from which to consider design trends of the car and truck of the future.

In the period of the first 14 years of this century, most of the lasting achievements were made by in-



An International tractor-truck hauls logs out of the big woods in the state of Washington

THIS FAMOUS TOWN* WAS ONLY A PRAIRIE until trucks came along!



But—LOOK AT IT TODAY!

See those flourishing stores—that proud bank—those busy merchants "stocking up" for the day? You can practically hear the hum of activity!

Seems hard to believe *this same spot* was just a field until trucks rolled in with everything needed to create this prosperous scene. But for *proof*—just read the true story below!

*COLLIER'S READER'S DIGEST ADVERTISING & SELLING . . . all have featured full-length articles about Franklin Square. Throughout America, this typical "Town That Trucks Built" is hailed as . . .

PATTERN FOR POSTWAR PROSPERITY

Everything the citizens of Franklin Square eat, use or wear is hauled to them by truck!

FRANKLIN SQUARE, Long Island, is the living symbol of over 50 thousand thriving American towns that *already exist today.* And of thousands more that *can* be built if trucks and highways are wisely put to work.

For here's a town that depends on trucks—and trucks alone. *There's no railroad!* Everything that rolls—in or out—of Franklin Square rolls *by truck.*

Result? Homes, goods, jobs for a prosperous and thriving community of 10 thousand people!

Today—thanks to trucks—America can put to use whole areas that are "off the rail line"—areas that might otherwise be wasted. New frontiers are opened up—new towns, new industries, new opportunities for our homecoming servicemen.

Yes! All over America—through peacetime and war—trucking is a dynamic economic force. Reawakening tired old communities—creating new ones. Stimulating jobs, industries, opportunities!

50 thousand towns like Franklin Square are proof of this fact: With good roads—and the freedom to use them—*trucking can do the job!*

THE AMERICAN TRUCKING INDUSTRY

AMERICAN TRUCKING ASSOCIATIONS, WASHINGTON, D. C.

TRUCKS CREATE NEW INDUSTRIES—NEW JOBS—NEW WEALTH!

dividual inventors. Often working alone, few were ever adequately rewarded for their labors. Yet the pattern of things to come was beginning to be clear, because some of the earlier failures were again taken up and made to succeed.

The second period saw the beginning of coördinated engineering effort demanded by the national emergency of World War I. The Liberty airplane engine was an example. On May 27, 1917, the Government asked a group of outstanding automotive engineers to develop an airplane engine. Through co-operative effort, the first production engine was delivered to McCook Field, Dayton, on Thanksgiving Day of that year. The Washington office of the Society of Automotive Engineers had participated in working out many of the details and in calling upon companies to assign men to the task. Although the war ended before many of the Liberties got overseas, it was a good engine by the standards of those days.

The third period saw the organization of great engineering and research staffs, and the building of huge laboratory and experimental facilities. General Motors, Studebaker, Ford, and a late-comer, Chrysler (with its almost legendary Zeder-Skelton-Breer technical triumvirate in 1924) led the way. Every major car and truck producer developed engineering and research organizations, as did the more progressive parts and components manufacturers. A few new companies came into the automotive picture, and many faded. By 1923, five years after the Armistice, the millionth Buick had come off the production lines, and Ford had produced 2,000,000 vehicles. Duco was first used as the Oakland's standard finish, ethyl gasoline was on the market, and four-wheel brakes had been introduced.

The production peak of cars and trucks was reached in 1929 with 5,358,420 units. Motorists had available all-steel bodies, hypoid gears, rubber engine mountings, adjustable front seats, hydraulic brakes, synchro-mesh transmissions, safety glass, and graceful styling.

The fourth period (during the present war emergency) has been marked by a vigorous coördination of the great research and engineering organizations of the automotive industry, in the interest of winning the war more quickly. Never has the nation seen anything like this pooling of technologies. Under the general supervision of the Army and Navy engineering staffs, new processes and designs, test data, and even experimental information have flowed freely between automotive companies. Management of the automotive companies has assigned more than 3500 of their best engineers to more than 1400 war engineering projects conducted by the Society of Automotive Engineers alone. The basic engineering work done will always be available to American industry, except for those studies which may remain under the cloak of Government censorship.

Actually a fifth period has already begun, because with cutbacks in weapon manufacturing programs many engineers have now been released for post-war projects. A total of 86 million motor vehicles had been produced by the American industry up to the discontinuance of civilian production, but never has the market been so hungry for vehicles as it is now.

To the galaxy of development engineers—both in and out of the automotive industry—will be added thousands of men and women who have had an introduction to new developments through military service and other war work. The ingenuity of this segment of the American population has been fired by making and using the motorized weapons which have helped in the achievements of the United Nations all over the world. These people will demand that tomorrow must give them something better than today's superlatives. They want progress and they will get it by being part of it.



Modern roads relieve traffic congestion by such devices as the Kew Gardens Loop on Long Island

Machine Tool Magic

Machines That Make Other Machines Have Progressed Rapidly During the War, Yet the Immediate Future Will Demand Continuing Supplies of New Tools. What Improved Machine Tools Mean to Industry and What May be Expected of Them in the Light of New Knowledge

HOUSEHOLD refrigerators will run so quietly that nobody will know when their motors turn on and off. They will have deep-freeze sections as standard equipment, too. Printing will be sharper, clearer, on more beautiful paper, filled with color, yet so inexpensive that every business house will be able to afford better work than the pre-war best. Automobiles will be lighter, faster, more durable, more economical, and much less troublesome in such small details as filling up the gas tank and keeping the brakes adjusted. Railroad trains will be faster, more comfortable, safer. Television sets will come in much sooner than anyone expects.

These and a thousand other post-war promises can be kept because just one industry—the machine-tool industry—can back them up. And right there is a story of what the automotive industry has done for the United States and perhaps for the whole world.

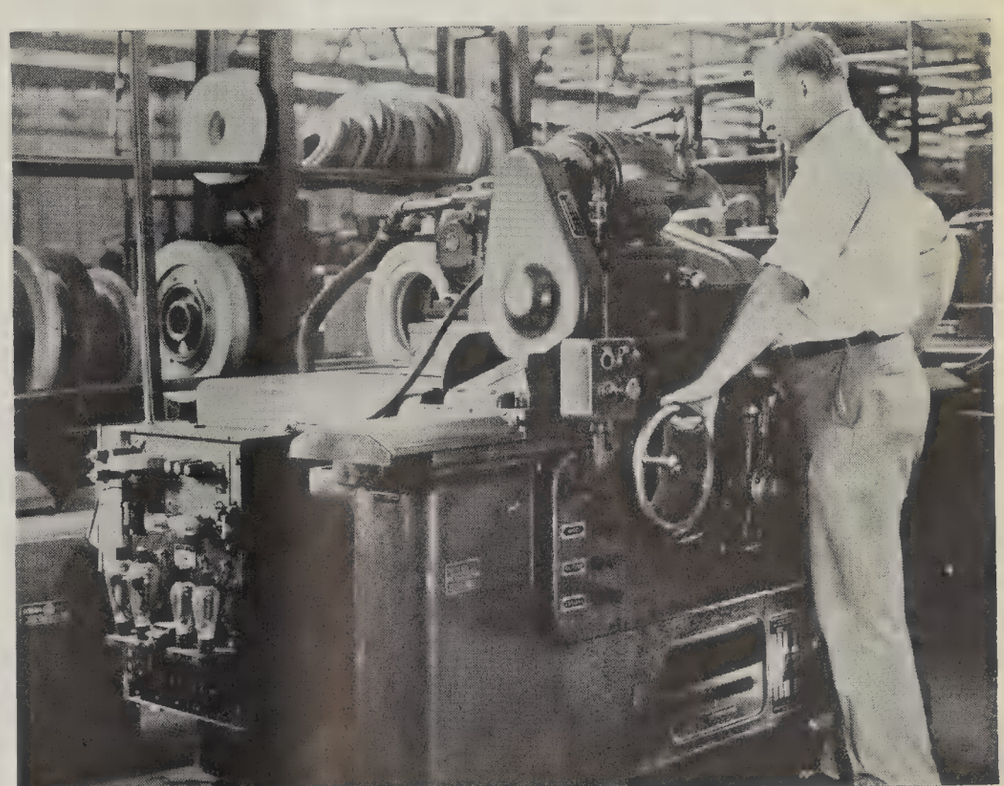
It was away back in the dim 1906 days of the automotive industry that dreaming executives began to see the real values of machine tools—machines that make other machines.

The slogans which the early automobile makers used show what they were thinking. Historians disagree as to who said what, whether any one idea was first expressed by Olds, Ford, Leland, Dodge, Willys, or any of the others who were equally great. But all of these men were saying "automobiles will be manufactured by men and power, and a machine tool is a means of submitting more power to the control of a man," and "no automobile ever will be as good as the machine tools that make it, therefore for better cars we must have better tools," and "as soon as we get the machine tools we want we can make good cars at any prices the public is willing to pay."

Ideas like this made the automobile industry the target of every machine-tool designer and maker who had brains. Cars got better and better right along with the machines that made them. And contrary to popular snap judgement the improved machine tools did not decrease either the amount or the wages of labor. Rather, in every case where direct comparisons could be made, it was found that the better the machine tools and the better the car the more the man hours of labor on it, even though the retail price went down.

Automobile makers ran dozens of small factories as well as their huge ones, and proved that superior machine tools work the same wonders in a small plant as in a large one. But from the viewpoint of the machine-tool builders, the trouble was that only a handful of industries (vacuum cleaner, refrigerator, radio, and the like) followed the automobile example. As late as 1939 more than 80 percent of the machine tools in use in the United States were over 10 years old and a big percentage were more than 20 years old. And with its products lasting that long and being allowed to get out of date that way, it was a good year when the machine tool industry had $350,000,000 in gross volume to whack up among the 200 or so machine-tool builders.

The war changed all this. Beginning with 1942 the entire metal-working industry of our nation became like one big automobile industry. Nobody cared what a machine tool cost, but many cared



Courtesy General Electric Company

Electronic control has made machine tools more versatile, more reliable

about what it would do. The object was to get out the most production, of the highest quality, and in the shortest time. All sorts of factories —tobacco companies, tire builders, railway shops, gas stove makers— got large quantities of machine tools and started producing shells, tanks, precision instruments, mechanical products of the most exacting accuracies. After learning the amazing things that machine tools can do, many an industrial executive made up his mind to have the full benefits of them in the oncoming peace-time.

BIG SALES—One of the first to feel this demand was the machine-tool industry itself. Its sales skyrocketed from $200,000,000 in 1939 to $1,322,-000,000 in 1942. Another billion dollar year was 1943, and 1944 followed along with $500,000,000 dollars worth of output. Half of this may have been special machines useful only for war contracts. But right now our nation has a full ten-years' normal output of machine tools of models less than four years old.

Strange to say, this surplus does not mean that the machine-tool industry will suffer from lack of normal business volume, excepting for the reconversion hiatus which may affect all industry. The progress of the machine-tool users who follow the course laid down by the automobile industry will be to find new and better ways to do many things, requiring continual supplies of new and better machine tools or at least drastic rebuilding of old ones.

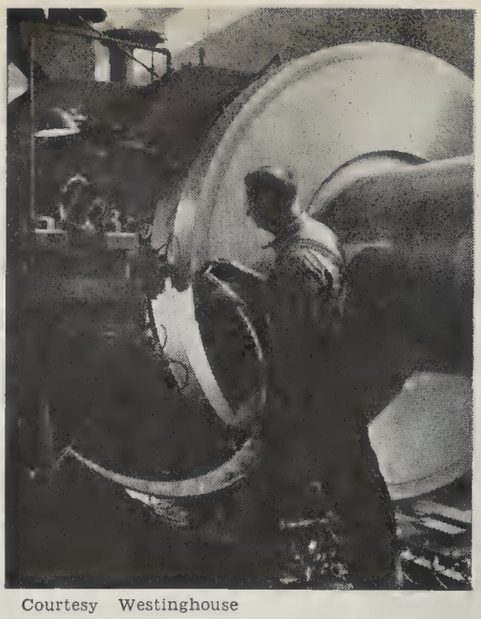
A large manufacturer of pumps is an example of what is happening. In the pre-war years this plant stuck to many a machine tool that was over 30 years old. Production lots of any one item were small, the line of products was highly diverse, and the management felt that it would do best with "old faithfuls" which its highly skilled mechanics knew exactly how to run.

The war changed all that. New machine tools came in and were installed right beside the old ones. And the better the mechanic the more advantage he took of rapid power traverses, pre-selectors of cutting speeds so the mechanic can set the speed for one operation while he is performing another and have that new speed come on automatically when he changes operations, one-shot lubrication so the whole machine is oiled or greased at a single push of a plunger, better lighting, more micrometric adjustments with magnifying glasses over their scales so they will be quick and easy to read, and other features.

It became certain that the company could make still more products and make them better, at lower prices, if it kept the new machines and discarded the old ones. But there always was the question of which new machines to keep.

CHECK LISTS—To settle this, the methods engineers worked out check lists of exactly what features any lathe, shaper, miller, or other machine tool should have to be ideal for the making of any one line of pumps in any department. These check lists showed the management a surprising fact.

There are few or no war-born machine tools which are ideal for peace-time use. The check lists showed blank space after blank space where no machine tools having all the desired abilities could be found.



Courtesy Westinghouse

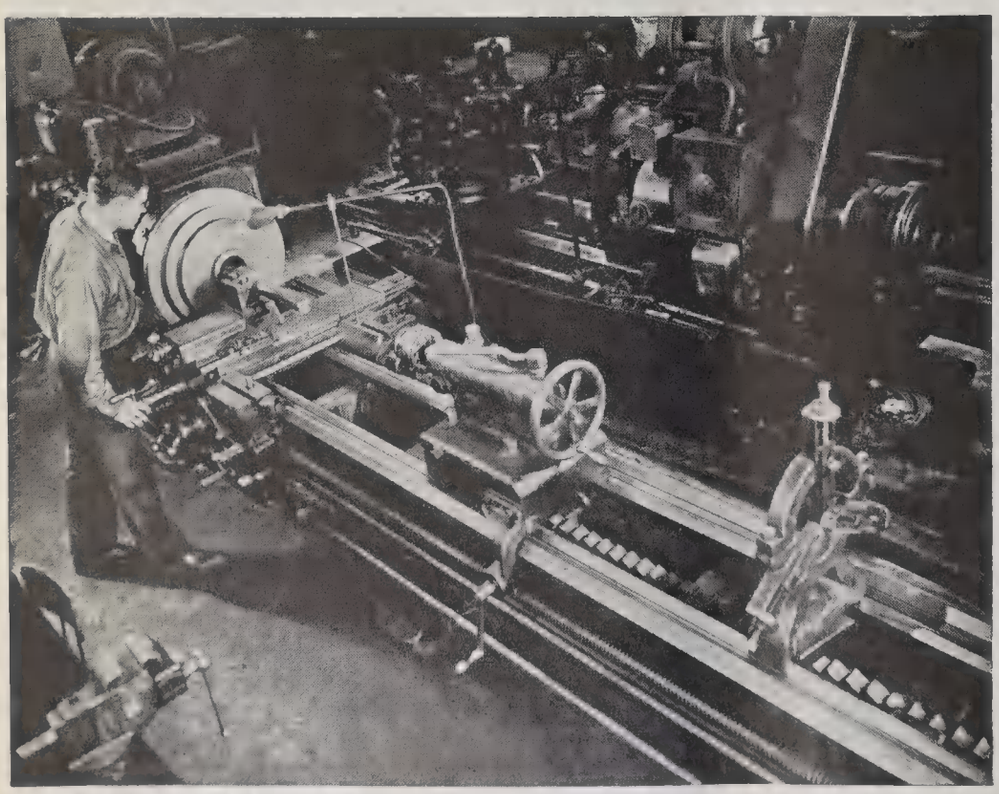
With this micrometer the 25-ton shaft of a vertical water-wheel generator is measured to .0005 inch precision

This manufacturer will use its war tools, or such of them as the government allows it to buy (many of the best machines will be taken over by the navy yards and the air forces) to earn money with which to buy new ones. But from the first minute of reconversion it will be looking for machine tools which can fill in the gaps in those check lists, challenging the design engineers of the machine-tool makers to work out new and better machines.

The schools in which mechanics and foremen are trained will change also. For years the fact that these schools were equipped with machine tools of ancient vintage has been a national problem. As far back as 1937, when the depression was still with us, the machine-shop managers of the nation were getting together and trying to find ways to modernize the schools so the skilled labor shortage could be relieved by a constant stream of modernly trained men.

Now those schools are to be equipped with government owned modern machine tools. They will not be turning out men who know how to work on ancient models. Their graduates will be trained to run the latest machines and to be quick about learning how to run still later ones. There will be skilled labor aplenty for shops which have late model machine tools but very little for those which stick to old methods.

MODERNIZATION—The railroads will modernize their shops too. It was the railroad repair shops which trained such automobile men as

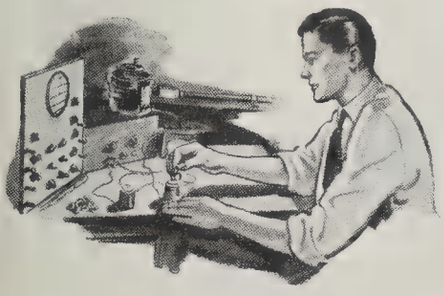


Courtesy Western Electric Comany

A lathe that can accommodate work up to 24 inches in diameter by 10 feet long

a nation-wide search for scientists of tomorrow

A MAJOR NEED of America today is the discovery and development of scientific ability among boys and girls now in high school. Real ability for creative research and engineering is rare. Many who do not now have the opportunity to develop their scientific talents will be discovered and made available for America's future progress through the Science Talent Search, conducted by Science Clubs of America and sponsored by the Westinghouse Educational Foundation.



WHY THE SCIENCE TALENT SEARCH WAS STARTED

The objectives of this unique search are threefold: to discover high school seniors of exceptional scientific aptitude – to focus their attention on the need for developing scientific knowledge and skill in research – and to make the American public aware of the importance of science in their daily lives.

HOW ENTRANTS ARE TESTED

Examination of entrants in Science Talent Searches is based largely upon rigorous science aptitude tests – to determine their research ability, reasoning powers and breadth of scientific knowledge. These tests are prepared by Dr. Harold E. Edgerton and Dr. Steuart H. Britt, prominent educators and psychologists.





HOW THE SEARCH IS CONDUCTED

Each year, high school seniors all over America compete for Westinghouse Science Scholarships, of a total value of $11,000, by taking these aptitude tests and submitting original science essays. Selection of the 40 finalists in the Annual Science Talent Search is based upon their records in aptitude tests, scholastic standing, recommendation of teachers, and science essays, in the order given.

WHAT IT HAS ACCOMPLISHED

To date, 160 brilliant youngsters–winners of Science Talent Searches – have been awarded $41,500 in Westinghouse Science Scholarships. In addition, 429 winners of Honorable Mentions in the *first two* Science Talent Searches have received scholarships, valued at $132,450, from other sources. Of perhaps greater importance, a continuing study of one of the early Searches has disclosed that more *than 75% of those who entered this competition have actually gone to college – against a national average of only 35% for high school students!*



Westinghouse

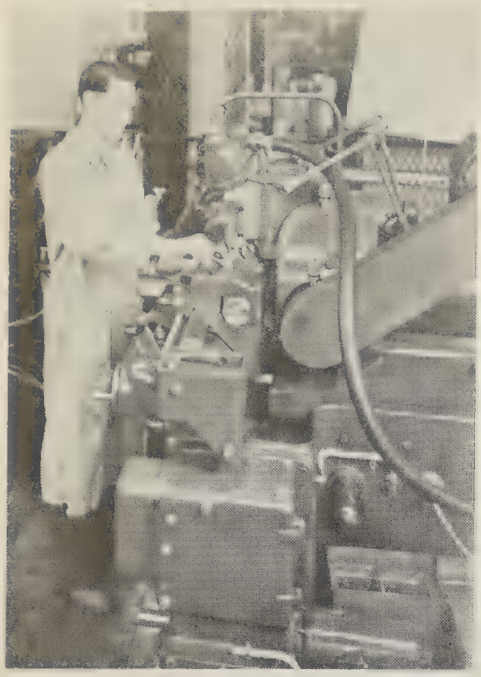
PLANTS IN 25 CITIES OFFICES EVERYWHERE

SEND FOR SCIENCE TALENT SEARCH LEAFLET

If you are the parent of a scientifically-gifted boy or girl who will be a high school senior this fall . . . or if you know of such talented youngsters . . . send for Science Talent Search Leaflet SA-85 which gives full information about these competitive awards. Write: Westinghouse Electric Corporation, Box 1017, Pittsburgh 30, Pa.



Tune in: JOHN CHARLES THOMAS—Sunday, 2:30 pm, EWT, NBC ▪ TED MALONE—Monday through Friday, 11:45 am, EWT, Blue Network



Precision in machine tools, such as this thread grinder at the Jones and Lamson Machine Company, insures precision in the final assembled product

Walter P. Chrysler and gave them their first modern methods mindedness. But later on a large part of those shops went into the doldrums. They had no money with which to modernize, and their old machine tools were adequate, with a few additions here and there, for the kinds of rolling stock the roads owned.

Now the railroads are modernizing their rolling stock. And the new equipment is made up of Diesel engines, turbo-electric engines, electromotive equipment, ball-bearing journals on cars—refrigerating and air conditioning equipment in cars—the kinds of mechanisms which can be built and repaired only by the use of the most modern, high accuracy machine tools.

The steamship lines are a similar case. Gone are the days when the chief engineer could repair his engines by using a Stillson wrench, a drill, a file, a torch, and a suitable assortment of other small tools. He has Diesels now, and highly complex electromotive drives, and turbines and other equipment which needs the very finest machine tools for overhaul and repair.

Everything, then, from the tiniest pump to the largest steamship engine, will require the most modern machine tools to build and to maintain it. And the benefits to everybody will be plentiful.

ACCURACY—Silence in all kinds of moving machine parts will be had from higher accuracies in their production and from the better balancing which is part of accuracy. Accuracy of operation is built right into modern machine tools; the skill of the operator is in the ways in which he directs that accuracy and not in the ways he obtains it.

Versatility with high speeds and accuracy is another advantage. Modern machine tools can be set up more quickly and for wider ranges of operations. This removes limitations from product designers—they can work out their consumer or industrial product ideas without worrying very much about whether or not the machine tools to make the resultant products can be had. It is the versatility of modern machines which will bring in television and the family airplane so quickly.

Complete dependability is another point. Thousands of mechanisms containing gears, bearings, and automatic control mechanisms will be completely sealed in the future, never to be opened for lubricating or other servicing until they have lived out long and trouble-free lives. Mechanisms can be sealed this way because the machine tools on which they are made are so completely dependable in the qualities and accuracies of the parts which are made on them.

Back of all the progress is a brand new factor in the machine-tool field itself.

Machine-tool makers have had decades of experience compressed into five short years. Where they used to make 100 or so of a new model and learn how to impove it by seeing it at work in a few automobile plants, they have made thousands during the war and seen them at work in hundreds of plants. Thus they have learned, years ahead of the normal time, what is good and bad in the new machine-tool ideas as well as some of the old ones, and how to make improvements.

WATER LUBRICANT

Can be Used
Where Bearings Permit

MAKING stern tube bearings for ships out of materials which can use water as a lubricant is an old trick. Yankees used lignum vitae for this purpose decades ago, and the later rubber and the phenolic resin impregnated canvas bearings of today are proving their values everywhere.

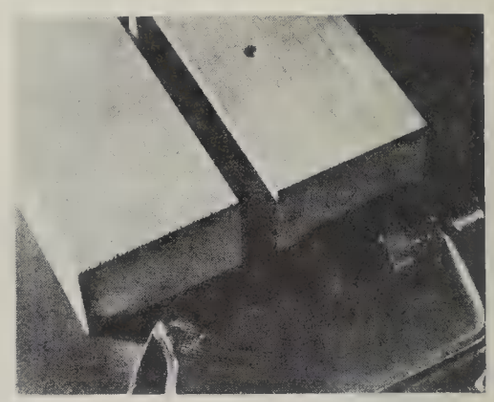
Industrial plants also use many such bearings on laundry equipment, chemicals process machines in which bearings must operate under water, food processing machines which must be washed so often that lubricant is rinsed out of ordinary bearings, and pumps which are exposed to the weather but seldom serviced.

New uses are being found on machine tools. Here the age-old problem is whether to use water soluble cutting oils which do not do very good jobs as lubricants of machine bearings, or good lubricants which will take care of the bearings but will not reduce cutting heat as thoroughly as the water soluble oils, or to shield the bearings so lubricant can be used in the "bearings end" of the machine tool and soluble oil in the "cutting end." The bearings which can use water as a lubricant are another solution of this problem, if they are not damaged by oil. And plastics bearings can stand either water or oil.

WOOD HARDNESS

Can Be Tested Easily
By a Simple Clamp

THE HARDNESS of wood can be tested by Brinell or by Rockwell instruments, provided the wood section is small enough to be brought to the instrument and the wood is not already fastened into a structure so that it cannot be moved. But when the wood is too large or is inaccessible to the instrument, another means of testing must be found.



Penetration measures hardness

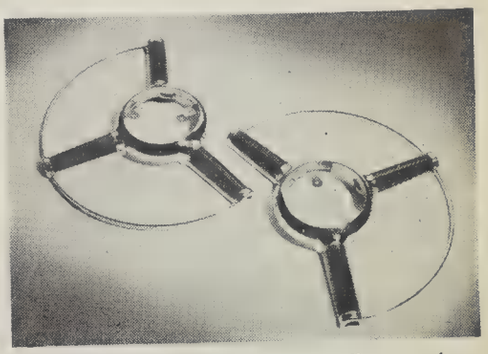
One simple testing means uses merely a C clamp. The clamp is placed on the wood and tightened with an predetermined force, the amount of penetration into the wood being an easily measurable index of the wood's hardness.

A more accurate amplification of this method employs a coiled spring which operates a moveable ball-pointed thrust rod at one end of the clamp. The pressure of this spring always will be a constant for any given amount of tightening of the clamp screw which opposes it, and therefore the penetration at a given spring pressure is known.

By measuring the indentation at the time it is made and then waiting 24 hours and measuring it again, the "spring back" of the wood can be determined.

Automotive Plastics

Will "The Car of Tomorrow" have a Plastics Body? Probably Not, Until Many Technical Problems are Solved. However, Even Pre-War Cars Used Many Plastics Parts, Pointing the Way Toward Vast Increases in the Use of these Materials for Decorative and Functional Purposes



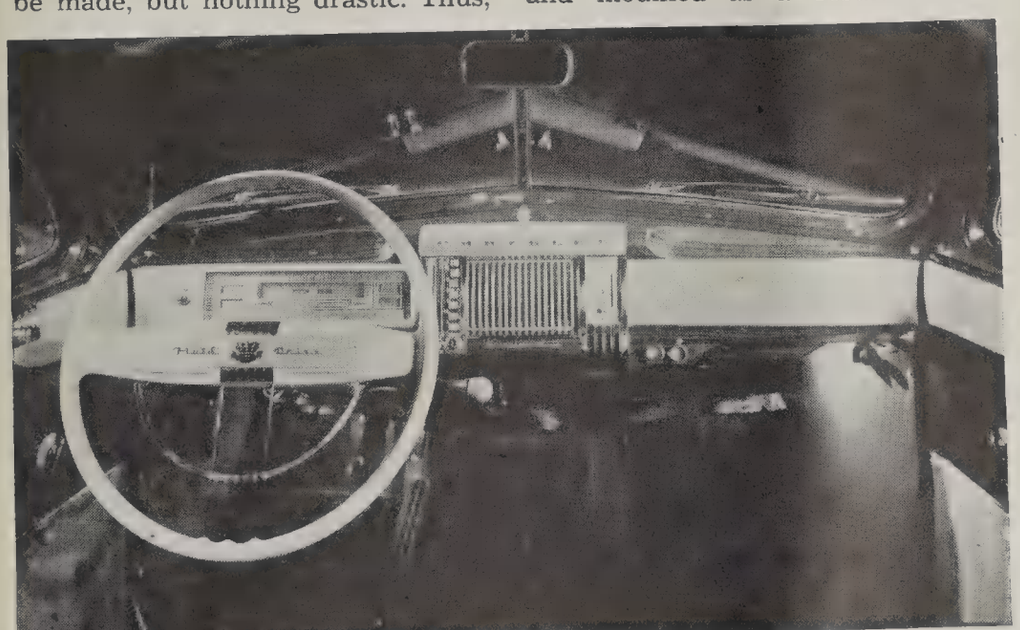
An attractive and structurally sound plastics and metal horn ring unit

TWO HUNDRED thousand new passenger cars by the end of 1945. Four hundred thousand more in the first quarter of 1946. Such are the latest predictions. Of course, since every one of these machines will go to war workers, government services, doctors, and other essential users, the average car owner realizes that he has little chance of obtaining one of these models. But the fact that new cars are going into production gives him a different attitude toward the machine that has seen him through the past few years. He suddenly is conscious of its shabby appearance, its eccentricities, its deficiencies. Suddenly he needs a new car. And what will this new car be like?

As the date for resumption of all-out automobile production draws near there is less and less talk in the trade of the revolutionary new car. Some companies are at pains to explain how similar the first cars off the production line will be to the prewar models. Slight changes will be made, but nothing drastic. Thus, it is only necessary to subtract age from the cars now in use to find the first cars of tomorrow.

On this basis, the cars of 1945 and 1946 will be equipped with a surprising number of plastics parts. Car owners have probably forgotten how sharp was the increase in the use of plastics in the 1942 model as compared to the machine put out the previous year. It was then, with metal beginning to be a problem, that automobile manufacturers gave increasing consideration to the color possibilities of plastics materials, to the wide range of applications in which they could be used, and to the low cost at which they could be formed.

During this period the automobile industry undertook exhaustive studies of all types, kinds, and classes of plastics. This research, combined with performance records of innumerable new applications, gave rise to more or less formal specifications. It is to be expected that these specifications will be expanded and modified as a result of the war-time experience of automobile manufacturers—changes which should work to the benefit of plastics materials in view of the record they have chalked up in airplane construction.



A pre-war instrument panel, made of injection-molded plastics with metal inlays

UNDER THE HOOD—Thermoseting plastics materials, both molded and laminated, have a long record of achievement in the automobile industry. The reason lies in their excellent electrical, mechanical, and chemical properties. For the most part these materials, the phenolics in particular, are used in conjunction with cam shafts, in distributor heads and other electrical assemblies, timing gears, washers, and insulation. They have, in addition, given outstanding service in brake linings. But while these applications are as essential to the successful operation of a car as the wheels or the engine itself, the public gives them scant attention. It is by the exterior of a car and the interior appointments that the majority of motorists pick their next car.

INSIDE AND OUT—It was in the exterior and interior appointments that plastics made their greatest gains in the automobile industry immediately before the war shut down production. When nine companies were interviewed just before the introduction of their 1942 models, all reported increased use of plastics in decorative applications. The cellulose acetates, cellulose acetate butyrate, and the acrylic resins in particular enjoyed a sharp rise

PLASTICS IN 1942 OLDSMOBILE MODELS

1. Dome lamp lens	U
2. Dome lamp switch cover and button	A
3. Regulator knobs	A
4. Regulator escutcheons	A
5. Regulator handles	A
6. Remote control handles	A
7. Rear quarter window adjustment knobs	A
8. Cowl ventilator control knob	A
9. Ash tray lid knobs—rear comp.	A
10. Window garnish rail medallion insert	A
11. Window garnish rail medallion insert	M
12. Windshield wiper control knob	A
13. Hood latch control knob	A
14. Light switch control knob	A
15. Cigar lighter knob	A
16. Gear shift knob	A
17. Ash tray knob—dash	A
18. Glove box door	M
19. Cluster lens	M
20. Steering wheel	A
21. Horn button	M
22. Horn ornament	M
23. Hydra-Matic shifter control box cover	A
24. Hydra-Matic shifter control box cover lens	A
25. Hydra-Matic shifter control box cover screen	A
26. Gear shifter knob—Hydra-Matic	A
27. Heater switch control knob	A
28. Defroster switch control knob	A
29. Fog light switch control knob	A
30. Radio tuning knobs	A
31. Radio selector knobs	A
32. Aerial escutcheon	B

A — acetate; U — urea; M — methacrylate; B — butyrate

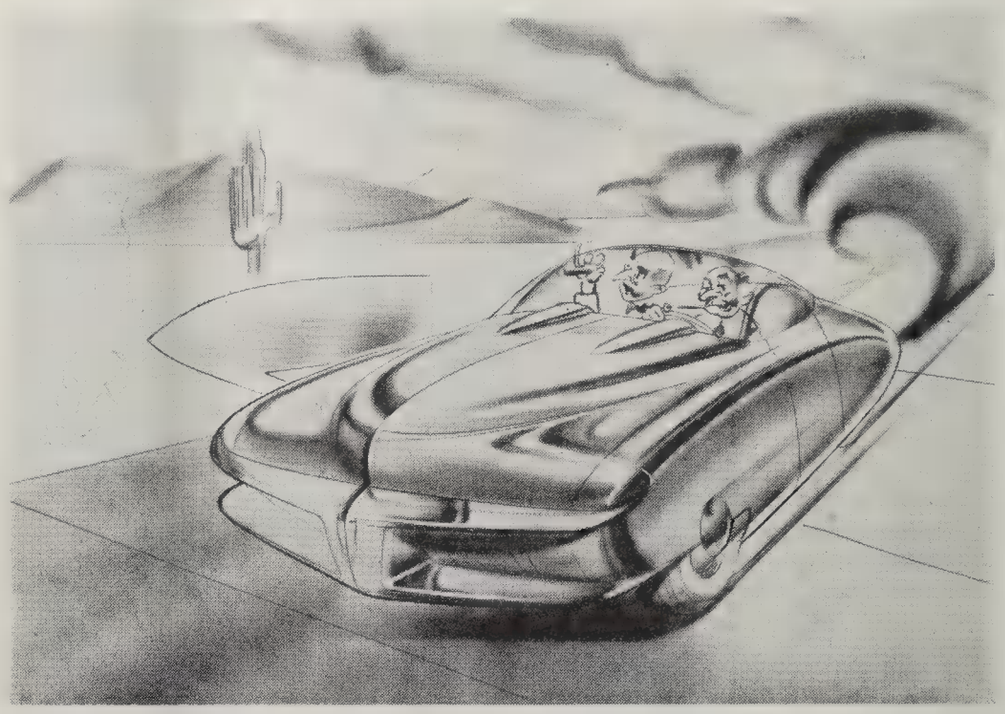
in popularity. As a matter of fact, applications of the acrylics in 1942 models were almost double those found in previous models—jumping from 39 in the 1941 models to 70 in the 1942 cars.

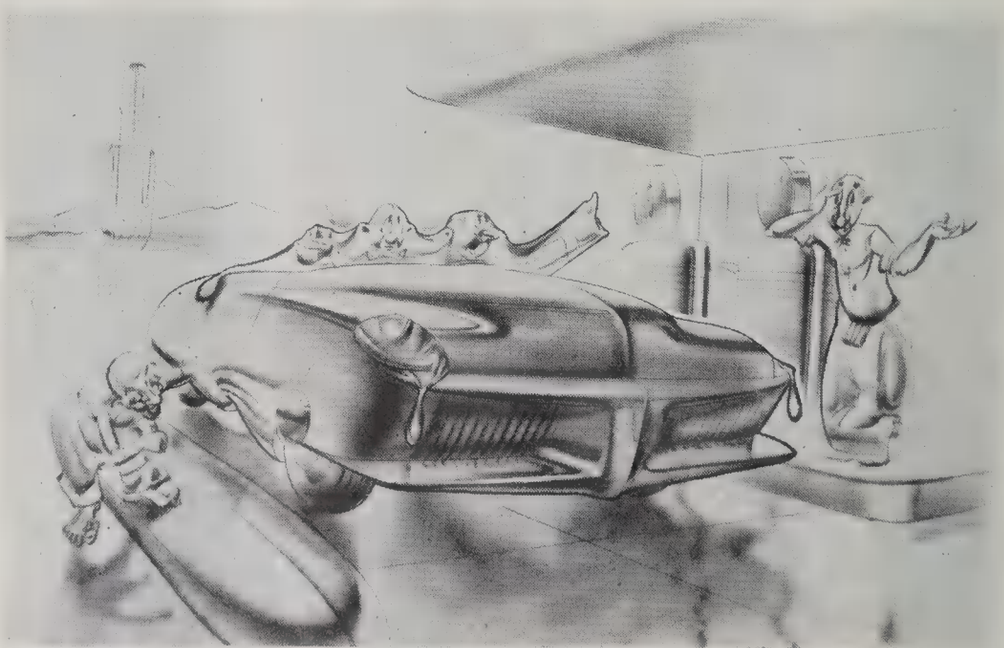
The uses to which the acrylics were put in these cars apply to the other plastics materials as well. Among these parts were radiator ornaments, parking lamp lenses, horn buttons, speedometer panels and dials, instrument cluster panels, clock panels and dials, medallions, radio lenses, indicator dials, horn rings, name plates of various types, and ornaments. Probably the best known plastics application is the steering wheel. In fact, many cannot remember when this part was made of any other material.

The accompanying table presents 32 decorative applications for plastics which were incorporated in the 1942 Oldsmobile and the material from which they were made. Outstanding in this list are the acetate window regulator handles and remote control (interior door handles) —instances where plastics were used to replace die-cast metals.

Plastics should hold their gains in these applications and they should step in and take a firm hold on another part of the interior—the upholstery. Fabrics woven from extruded plastics monofilaments are today giving good performances in many public conveyances. Not only do they wear well but they are easy to clean, a consideration which should make them popular in the cars of families with small children. They have the added advantage of color fastness and resistance to dampness. In fact, everything seems to their advantage as car upholstery material.

The automobile industry has been somewhat cautious in undertaking the use of plastics for exterior applications. The transparent cellulosics, by virtue of their clarity, were from the beginning interesting materials. They were used very early in sheet form for side curtains in the popular touring car. In





These two cartoons, used by Carl Sundberg, of Sundberg-Ferar, to serve as a warning against spreading misconceptions of what plastics can and cannot do for the automobile industry at present, tell the following tongue-in-cheek story: Above: Two post-war prophets start out in their all-plastics automobile for a road test across Death Valley. Note the smooth, flowing lines of the perfectly shaped body, possible only because it is injection-molded, in one piece, of transparent material. This handsome thing is painted from the under side and features name-plates, trim, and so on in bas-relief. In reality, the body is but a coat of paint protected by a covering of transparent plastics. Below: Note the smooth, flowing lines of the post-war Plasticar as it pulls into Death Valley Louie's a half-hour later. The prophets have a car with a top that now fits not only the body but their heads and shoulders as well. Oh, well, it's just the first rough model and there are still a few bugs to be worked out. Anyway, look at small fry gathering up the side panel for a look at the chassis. This gives the boys an idea: Now they can go to work on a body that needs only to be peeled back for a look at the motor, for minor repairs, or for changing a tire!

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

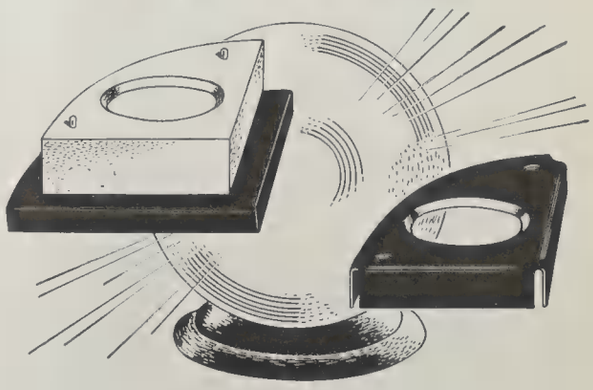
MOLDING COMPOUNDS



SWEET MUSIC FOR THE DESIGN ENGINEER

Just as this Durez phenolic plastic clarinet plays sweet music, so do thousands of other products molded of Durez. Only in these latter cases the sweet music is referred to in the figurative sense, for we're talking about the versatility of the Durez phenolics used . . . versatility that covers a wide range of highly desirable properties . . . versatility that is truly sweet music to the imaginative design engineer. Such characteristics as excellent dimensional stability at temperature extremes, lustrous finish, excellent moldability, dielectric and impact strength, and resistance to moisture, chemicals, and heat—to mention a few—are inherent in all of the more than 300 Durez molding compounds . . . are responsible for the use of Durez on a scope that is practically all-embracing throughout industry.

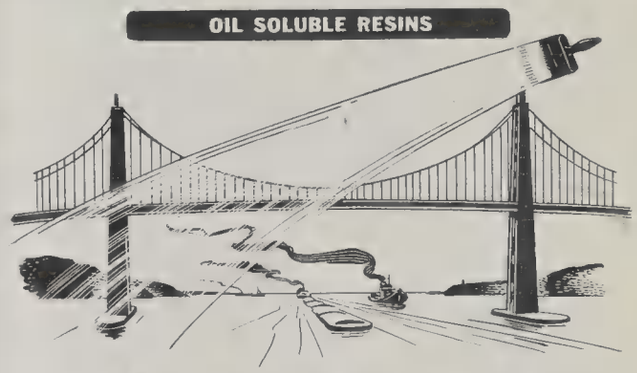
INDUSTRIAL RESINS



THE DIE IS CAST FOR CASTING RESINS

There's a bright future in store for users of the new Durez casting resins—for these remarkable resins substantially reduce production time and costs when used for such items as hydropress and stretch-press dies, jigs, assembly and holding fixtures, foundry patterns, and masking shields for plating.

OIL SOLUBLE RESINS



PROLONGING THE LIFE OF A SPAN

The durability and corrosion resistance which Durez resins impart to bridge paints make them real life prolongers . . . keep repair and maintenance bills at a minimum. The remarkable properties—such as acid, alkali, and water resistance—which Durez resins impart to paint, varnish and lacquer—have resulted in their extensive use throughout the protective coatings field.

● If you're looking for a versatile plastic material, the place to start is with the phenolics, for these are the most versatile of all plastics . . . and when you look to the phenolics, look to Durez—specialists in this field for the past quarter century. When you add the versatility of the more than 300 Durez phenolic molding compounds to the multi-propertied Durez industrial resins and the unusual protective values of Durez oil soluble resins, you can understand why manufacturers everywhere come to Durez for plastics or resins to fit their jobs. The background of Durez technicians includes successful product development experience throughout practically all fields of industry . . . product development experience that has resulted in the continuing leadership of Durez phenolic plastics and resins. The benefits which this wealth of experience and a large accumulation of proved data can provide are available to you, your designers, and engineers at all times. Durez Plastics & Chemicals, Inc., 528 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

molded form they were only just coming into their own when civilian automobile production was halted. Examples are cellulose acetate light lenses, fender lights, and rear deck directional signals; acrylic directional lamps; and radiator ornaments.

THE FUTURE—It is possible that some day entire automobile bodies will be made of some plastics material, but the accomplishment of this is so remote to be deserving of only "possibility" thinking. There has been the suggestion that bodies be produced by low-pressure molding of plastics-impregnated fibrous material of various kinds. However, putting technical consideration aside, the optimum molding cycle is, at present, far too slow to keep pace with automobile production.

When Carl W. Sundberg of the firm of Sundberg-Ferar, industrial designers, used the two accompanying cartoons of the Plasticar to illustrate an address before the Detroit Society of Plastics Engineers, his purpose was not to ridicule the concepts of progressive designers nor to deprecate the properties of plastics materials. Mr. Sundberg wanted, as he explained, to point out "the harm that is done by the representation to the public of unproved ideas in the name of promises for the immediate future." The industrial designer who wants to promote the increased use of plastics in the automobile or any other field can best serve both the industry and the consumer by recommending the right material for the right job.

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SUN-LAMP

Portable Type Designed For Traveler's Luggage

THE DAY is fast approaching when an ultra-violet ray lamp will be a standard part of many travelers' baggage. The Sun-Kraft, Inc. has completed production plans for just such a unit which will be housed in a two-piece case molded of colored urea-formaldehyde.

This portable lamp will be equipped with adjustable plastics arms so designed that they fold away inside the top of the case when the lamp is not in use, yet can support the cover and the reflector housed therein at any desired angle when the machine is in operation. The over-all outside dimensions of the lamp will be but 10⅛ inches long, 5½ inches wide, and 5½ inches high. The high frequency oscillator circuit will be positioned in the lower half of the case; the reflector, adjustable arms, and part of the timer in the upper half.

RADIO MASTS

Made of Plywood Tubes Are Light in Weight

BECAUSE extra ounces of weight can be a serious hindrance to our soldiers, many of the radio antenna masts used by the United States Army Signal Corps are being made of plywood sections which can be dismantled and nested in a compact box. These masts, some of which are 50 feet in height when set up, are formed by Plymold Cor-



Plastics radio mast packed in chest

poration of thin layers of wood veneer impregnated with urea-formaldehyde resin by a special process.

After impregnation the layers are wrapped spirally on a mandrel in such a way that some of the veneers are parallel to the axis of the tube, some are at right angles, and some are at 45 degrees to the axis. This three-phase construction is said to give to the Plytube a strength approximately the ultimate strength of wood. Even when packed with auxiliary equipment in two fitting chests, the 50-foot mast is considerably lighter than the equipment previously in use.

POCKET COMPASS

Light, Precision Made, Popular with Air Corps

ONE OF the most popular items with the Army Air Corps is a pocket-size, dial type, liquid compass, attached to a case which holds small water-proof matches. Together with case it weighs less than two ounces and resembles a flashlight battery. It is three inches high and one inch in diameter. Military specifications for this pocket compass call for the same rigid tests as those given to standard compasses on B-29's and other fighting aircraft. Such a fine degree of accuracy is required that a variance of .0005 inch would result in rejection. This is necessary because the all-purpose pocket compass must be able to stand up under all sorts of service conditions.

The compass, which containes 16 separate parts, is injection molded of Tenite II at a slow cycle to keep maximum dimensional control. The units are produced at the rate of 2000 daily by DuPage Plastics Company. The sighting window on the compass is Lumarith.

TRANSPARENT PLASTICS

Protects Workers From Flying Chips

AS A protection to machine workers, the Dilley Manufacturing Company has introduced a magnetic grip shield consisting of a thick sheet of Plexiglas anchored to a horseshoe permanent magnet. The magnet holds the transparent plastics shield in position between the worker and his machine. In this way flying fragments of steel, wood, and so on, are deflected while at the same time the operator of the machine has an unobstructed view of his work.

PRE-HEAT

Controlled Electronically at Plastics Molding Press

ELECTRONIC heating equipment has been successfully used for several years in pre-heating plastics molding briquettes just before they are placed in the molding press. At first, relatively high-power equipment was needed because the blocks of plastics material took more and more power as they swelled and changed in electrical characteristics during the heating process.

Now, however, electronic control equipment recognizes each change in the plastics material during heating and automatically tunes the electronic generator for maximum operating efficiency so that peak power is utilized throughout the entire cycle. Several experimental installations have already been made in the Boonton Molding Company plant with excellent results.

With this arrangement, bulky electronic generators can be located outside the crowded molding shop, away from dust and steam, and the radio-frequency power can be fed through transmission lines to small and simple heating heads located alongside each press. Heating heads can be interlocked so that only one is used at a time but all receive power in sequence for maximum utilization of a single generator.

Petroleum Pavements

Asphalt in Varied Consistencies, Distilled From Petroleum, Surfaces Many Thousands of Miles of America's Highways. Quickly and Economically Laid in the Molten State, it Forms a Resilient and Flexible Road-Bed Whose Cushioning Surface Wears Long Under Constant Use

THESE days everyone seems to have a preferred label for the contemporary world. Some call it the age of steel and some the age of electricity. Coal men insist that it is the age of coal while fliers assert that it is the epoch of aviation. But whatever other title may be given the present-day world, there is no doubt that it is the age of the internal-combustion engine. In America millions of automobiles roll along thousands of miles of hard-surfaced roads. Petroleum furnishes the motive power and, in the form of asphalt, it furnishes a large part of the wear-resistant road surfaces.

Asphalt's most valuable attribute as a paving material is its flexibility and resiliency. These qualities enable it to remain in contact, under severe stresses, with the supporting earth beneath it. A rigid material would be forced to bridge every shrinkage of the road's foundation or break under the strain.

There are approximately 647,000 miles of road in the United States whose surfaces are better than ordinary gravel. Bituminous products are used on 524,000 miles of these roads, and approximately 87 percent of these bituminous road-surfacing materials are derived from petroleum. Asphalt covers two thirds of the improved mileage of state highway systems, and nine tenths of county and town roads. The streets of America's busy cities are covered mainly with asphalt—four fifths of them, in fact.

Manufacturing and distributing the vast quantities of asphalt used for these purposes is an important part of America's great petroleum industry.

It is believed by many that most of the asphalt used for paving our streets and roads comes from the "pitch lakes" of Trinidad, Venezuela, and California where it is found in the natural state. As a matter of fact, these lakes ceased to be important sources of asphalt many years ago. By 1940, according to figures of the United States Bureau of Mines, 93.5 percent of the asphalt processed in the United States was derived from petroleum through refining methods while the balance came from natural deposits.

After the refining of petroleum became a major industry, asphalt remained for a long time a much disliked and relatively useless sticky substance that had to be grubbed laboriously out of the bottoms of stills after the distillation of crude. Today asphalt is one of the most widely used of petroleum products. Asphalt in the natural state, obtained from asphalt lakes, was originally formed by crude petroleum seeping through cracks and crevices in the earth's strata and collecting in pools exposed to the sun. The lighter fractions were distilled away by the sun's heat. The natural asphalt remained as a residue. To be useful, it must be mixed or "fluxed" with a heavy oil or a soft asphalt from the petroleum industry.

FROM CRUDE—Asphalts produced by the petroleum industry in the process of refining crude are composed of the highest boiling petroleum hydrocarbons. In the laboratory these can be separated into three groups known as "oily constituents," "resins," and "asphaltenes." The smaller the content of oily constituents, the harder the asphalt and the higher its softening point. Asphalts vary in consistency from a semi-fluid to a brittle solid. They do not react with acids or alkalis. Their ability to repel water is one of their most important properties and their



This modern road-building machine scoops up the materials laid out before it, mixes them with asphalt in the desired proportion, and spreads the finished product

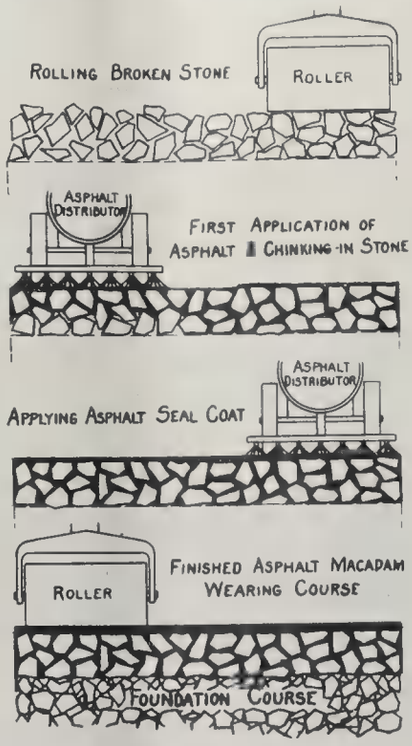
high adhesive qualities serve to bind together the aggregates used in road construction.

The starting point in the manufacture of asphalt from crude is the residue, known as reduced crude, left after the distillation of crude petroleum in a bubble tower. This residue is usually a heavy liquid. It is further processed by additional distillation or by blowing with air while in a heated condition. The blowing operation is conducted when the residue is heated to a temperature between 400 and 500 degrees, Fahrenheit. At that temperature the air reacts chemically with the material to produce an asphalt with a higher softening point than would have been produced by straight distillation. As the softening point is increased, the asphalt becomes harder as indicated by penetration tests. Asphalts obtained in this way are known in the industry as blown asphalts.

An alternative distillation process is carried out in a pipe still. In this operation reduced crude is pumped through a coil of pipe heated in a furnace so that its outlet temperature is about 700 degrees, Fahrenheit. As the reduced crude emerges from the coil it is sprayed into a large tank known as the flash tower where an instantaneous separation takes place between the asphalt and the heavy distillate oils in which it was dissolved. The recovered asphalt falls to the bottom of the tank and is drawn off to storage. Its hardness is controlled by the maximum temperature to which the reduced crude is heated in the pipe still.

The characteristics of a finished asphalt product can be altered markedly by varying the degree of distillation or blowing used in its manufacture. In the blowing process, the oxygen in the air combines with some of the hydrogen atoms of the asphalt molecules to form water which is removed as steam. The removal of hydrogen atoms is believed to convert oily constituents to resins and resins to asphaltenes. In this way the softening point is increased by increasing the proportion of resins and asphaltenes in the asphalt and not by stripping out oily constituents as in the case of straight distillation.

MACADAM'S IDEA — Until the emergence of the automobile age, the greatest road builders known in history were the ancient Romans who traveled far, and for their times, extremely fast, and realized the value of straight, solid roads. The celebrated Appian Way was a causeway made up of rigid layers of stone three feet thick. The Roman idea that roads had to be thick and heavy persisted among engineers up to the 18th Century when an ingenious Scot, John MacAdam, thought up a better and actually new way of constructing roads. He decided that the earth itself should support not only the pavement, but the traffic that moved over it.



Steps in paving with asphalt macadam

To accomplish this, he made his road surface a light stone shell in place of the massive Roman construction. The big thing in MacAdam's road was to see that the earth remained dry and firm underneath the surface. He found that by breaking the stone into fragments, their angular faces could be forced together to join in an interlocking crust and that rock dust, when wetted, would form a cement to fill the voids and thus provide a relatively thin, impervious crust sufficient to sustain traffic while it rested on the dry, firm earth underneath.

As the friction of iron shod-wheels and hooves wore away the rock, it provided new dust to cement the surface. The coming of fast-moving, rubber-tired autos to the macadam highways raised a problem. They whirled the rock dust high and far, and the soft rubber wheels did not abrade the surface enough to produce a new supply. Asphalt came to the rescue and entered upon the era of its greatest usefulness to humanity. Melting it in small pots, engineers poured it over the crushed stones of macadam roads to bind them securely, yet elastically together, forming a cushioning, tough, and water-repellent surface.

At first the asphalt was heated and poured laboriously and tediously by hand. Improvement and mechanization of the work was rapid, however, and today a modern distributor with a crew of six can apply 70,000 square yards of material in an eight-hour day. Working with old-fashioned hand pouring pots, the same number of workers could treat about 1750 square yards.

Meanwhile, research workers were busy improving asphalt for paving uses. Road builders had complained that heating and softening asphalt


Left: A modern asphalt plant capable of turning out 1000 tons of hot mixture every day


Right: Sheet asphalt looks well, and serves long, on this wide suburban street

to get it to the desired consistency was expensive and slow. The technicians sought an easier way to achieve the same ends, and found it in solvents. They added gasoline to asphalt and called the product "cut-back." The new material could be laid cold since the gasoline would evaporate and leave the asphalt binder in place. This discovery vastly widened the uses of asphalt for road building.

The technologists then observed that the *rate* of evaporation or setting was important. With an excess of small gravel and dust, the gasoline evaporated too quickly, and so they added kerosene as an additional solvent. Finally they classified all cut-backs into groups—the slow-curing, the medium-curing, and the rapid-curing. In 1942, before war needs had seriously reduced both the amount of petroleum available for road surfacing and the number of workers engaged in that activity, more than 2,200,000 tons of cut-back were used for paving in the United States. Total consumption of all types of paving asphalt amounted to almost 5,600,000 tons.

PAVING PLANTS—A great deal of the asphalt laid on country highways and city streets is prepared in paving plants. These may be described as factories for turning out paving mixtures in accordance with the requirements of road engineers. Today they operate on Diesel or electric power and the stone and sand is fed into mixers by automatic feeders. The dryers are heated by oil-burning furnaces. The stone is separated by vibrating screens; precise weighing machines, sometimes controlled photo-electrically, accurately proportion the materials and mixing cycles. A modern asphalt plant with a capacity of 100 tons an hour can be operated by five men.

In many coastal regions, such as Cape Cod and the eastern Carolinas, stone is absent or scarce, and sand, though abundant, is not of standard grading. Road engineers and asphalt technologists found ways to deal with this problem. Methods were devised to obtain firm, dustless surfaces from mixtures of local sand and bituminous materials. A similar problem was found in the sand hills of Kansas and Nebraska, where fine blow sand was all that could be had for road building. Here, too, a method was developed to blend asphalt with the sand to provide thin, firm mats for high-speed roads. Along the Mississippi River, great dykes or bluffs of a fine wind-blown dust known as loess seemed to have little practical use. Then engineers found it made an admirable filler for pavements and its use has cut road costs in Mississippi.

In addition to its big job of surfacing roads, asphalt has other uses in the field of automotive transportation. It goes into battery boxes and brake linings, enamels and paints, as well as panels and accessories. In the manufacture of synthetic rubber tires, it is used as a contributing material under the popular label of "mineral rubber." Asphalt thus is made to roll on asphalt.

The post-war prospect for asphalt seems to be one of expanding use and consequently greatly augmented production. The manufacturers of petroleum asphalt, according to the Asphalt Institute, are getting ready to supply a demand, once hostilities in the Pacific cease, greater than any that existed before the war. The civilian airports of the future will consume vast quantities of asphalt for runways and taxiways. The country's highways, after the neglect caused by the urgency of devoting materials and labor to the needs of war, will need widespread repairs and resurfacing. Above all, a new America on wheels will require thousands of miles of new roads. Asphalt and the asphalt makers will be busy as beavers doing a better job than ever.

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AIRCRAFT LUBRICATING

From Central Source
Cuts Operating Costs

ADAPTATION of centralized lubrication to aircraft makes it possible to lubricate many bearings from a single source. Many points formerly lubricated only when the aircraft was on the ground can now be lubricated during flight. The system delivers a predetermined amount of lubricant to each bearing.

Replacement of worn bearings and parts, due to faulty or neglected lubrication, has been a major expense in aircraft operation and upkeep, according to Alemite engineers who have worked with aircraft manufacturers in developing the new method of lubrication. This expense has been due to inaccessibility of lubrication points which encouraged neglect, use of improper lubricants, and over-lubrication, with resultant safety hazards.

One example of time-saving as a result of the new system involves the engine cowl flap rings of a two-motored aircraft. Each cowl ring has 24 plain bearings and one actuating gear box, or 25 points of lubrication. Time required for a mechanic to lubricate the twenty-five points has been reduced from 45 minutes to one minute. Added weight caused by installation of the Alemite centralized system is said to be negligible, especially when viewed in the light of time savings and efficiency. In the case of the engine cowl rings, only 2.5 pounds per ring or 1.6 ounces per bearing were added.

OIL EXPORTS

Expected to End After War
To Conserve Resources

THE UNITED STATES will virtually cease to supply Europe with oil after the war, was the conclusion reached after a recent survey of European post-war petroleum problems. War-born producing and refining facilities in the Middle East and in South America probably will absorb a substantial part of these peace-time markets, the survey revealed, according to *Ethyl News*.

"Conservation of proved oil reserves in the United States, it is believed, will be the order of the day in the post-war period," the publication points out. "There will be no exportable oil, except specialty products, and the country must be prepared to fuel another war if that ever becomes necessary.

"This condition, translated into pre-Pearl Harbor days, means that the United States stands to lose an export business in oil products approximating more than 200 million barrels, excluding such by-products as grease, wax, petroleum, coke, blending agents, and asphalt."

CASH REGISTER TEST

Helps Oil Refiners
In Post-War Planning

IN MODERNIZING and revising equipment to meet post-war competition, oil refiners must be sure that their plans are both technically and economically sound. To help them in this task, the M. W. Kellogg Company, petroleum and chemical engineers, have a yields and economic division, whose function is to put "the cash register test" to the recommendations of the process engineers.

The workings of this department are shown in a recent typical economic study of refining operations. Consulted by a refiner-client as to what steps that company should take to improve its process position, Kellogg engineer-economists developed three alternate new operations increasing the firm's net operating credit by $3,295,000, $3,913,000, and $3,908,000 respectively.

Electronics On The Road

Two-Way Vehicle Radio Units, the Walkie-Talkie, the Handie-Talkie, Electronic Ignition Systems, and Safety Devices are Some of the Developments that May Well be Expected to Make Commercial Vehicles More Versatile, Motor Cars More Efficient, and the Highways Safer

By JOHN MARKUS
Associate Editor, *Electronics*

IF JUST one electronic unit gets onto the mass-production dream car of tomorrow, there is every prospect that another market approaching the magnitude of entertainment radio will unfold for the fast-expanding field of electronics. The possibilities of radar must be discarded at present for automobiles. The equipment is too costly and its abilities at present do not lend themselves to any sort of detection, safety, or control function at mile-a-minute speeds on highways. Probable future advances in highway transportation lie in two things—radiophone communcation from one vehicle to another or between vehicles and the telephone system of the nation, and electronic devices for making motoring safer.

The Bell Telephone Company of Pennsylvania intends to offer radiotelephone service for trucks, buses, other commercial vehicles, and private automobiles on a fixed-fee basis similar to existing business telephone service charges. Company officials hope to have the service available by the end of 1945

Initially, master high-frequency transmitting and receiving stations will be installed in Philadelphia and Pittsburgh, with switchboards linking these stations to existing telephone lines. Each vehicle participating in this mobile radiotelephone service will carry its own compact high-frequency transmitter and receiver, with a whip antenna and dashboard telephone handset much like those used on police cars today.

Present plans call for service covering only vehicles traveling within a radius of about 15 miles of a central station. Through the central switchboard, a person at practically any telephone in the United States will be able to talk to the driver of any radiotelephone-equipped car within the service areas of the master stations. Later it is planned to establish relay stations or additional master stations in other areas to extend the service.

In Cleveland, the Yellow Cab Company is now successfully using Motorola frequency-modulation two-way radiotelephone units for dispatching cabs with a minimum of dead cruising for customers. Talk-back from driver to dispatcher is clear and distinct over the entire Cleveland area even though both the mobile and fixed transmitters have power outputs of only 15 watts. Reception is free from both natural and man-made static interference, indicating a promising future for frequency-modulation radio units cruising on streets and highways.

The FCC plans to assign channels for this type of service on an experimental basis pending final determination of the best method of operation—12 channels for development on a common carrier basis, four for trucks, and four for buses. In all, 40 channels will be available for general highway mobile use, the other 20 being in the band from 30 to 40 megacycles which can be picked up on the average home all-wave radio set. Unless speech-scrambling equipment or other electronic message-secrecy devices are employed at these lower frequencies, private word or number





Right: Dashboard installation of a radiophone handset in a Cleveland cab. Left: Two-way radiophone equipment in the luggage compartment of a cab, showing the compactness of the 15-watt Motorola transceiver which has its own dynamotor (in foreground) for supplying the high voltages required by the radio tubes

codes may well become the vogue for highway radio service.

Other commercial applications for highway radio include physicians' automobiles, ambulances, express and other delivery services, and expansion of the already widespread use of radio by repair trucks and patrol cars of street railway systems and other public utilities.

Even in the present stages of development, the entire equipment for radio service in a private automobile takes up less than half the space in the luggage compartment at the rear. The equipment operates directly from the storage battery in the car, and has its own dynamotor for generating the higher direct-current voltages required by radio tubes. When mass production of two-way car radios gets under way, it is highly probable that the equipment will be made still more compact.

NATION-WIDE — American Telephone and Telegraph Company has worked out elaborate plans for a network of automatic radio relay stations all over the country, spaced about 18 miles apart, so that motorists equipped with two-way radio can telephone from their moving cars anywhere in the country to regular telephone subscribers.

To make a call from his car, the driver would signal the operator at one of the control stations into which the relay stations in a given region feed. The operator would then put the call over the regular land line to whatever telephone subscriber is desired, with long-distance calls being made just as easily as from your own home. This means that, when world-wide radiotelephone service is resumed after the war, a person driving along some charming country road in, say, Minnesota could chat with a friend in Java without even stopping the car, assuming, of course, that his credit was good with the telephone company.

CITIZEN'S RADIO—Personal two-way radiophone communication between civilians, recently provided for in frequency allocations of the FCC, permits a nontechnical person to operate his own radiotelephone transmitter.

Licensing requirements are simple: the station license requires only that the owner be a citizen of the United States and the operator's license merely involves passing a written examination in radio laws, much like an auto driver's examination.

The present military version of the citizen's radio is built like a French phone, is called a handie-talkie, and resembles in some ways the small personal radio receivers that came on the market just prior to the war. The citizen's radio will have its own batteries and antenna, along with a built-in telephone transmitter and earphone. Although the reliable range of present models is necessarily small, about one mile under average conditions, such sets allow mobility that no other radio equipment permits, as the Army has discovered.

Possible uses for these tiny radiophones are almost unlimited. Already they have been used by newspapers to transmit spot news directly to the copy desk from the scene of action, to replace regular telephone lines in an aircraft plant pending repairs after a fire, and to direct the operator of an overhead crane in a big factory from any point on the floor.

Storekeepers could use the sets for routing deliveries and pickups, to eliminate the time wasted by drivers in going to telephones or returning to headquarters for further orders. Clerks could get in touch with floorwalkers and section heads by radio, eliminating the oftentimes long delays of call systems and repeated telephone calls for roving personnel. Constructions crews on bridges and buildings likewise could profitably use walking radiotelephones for intercommunication and for contact with foremen and supervisors.

The cost of a civilian handie-talkie can be computed roughly in terms of the popular pre-war personal receivers, which sold at an average price of $20. Technical differences in construction and circuit design indicate that prices starting at $50 post-war for a two-way self-contained midget radiophone are feasible.

The Army walkie-talkie also commands high civilian interest, because of its much greater range. This set must be carried in a pack on the operator's back because it is larger and contains heavy-duty batteries. Farmers and ranchers having employees who are miles apart during working hours can use two-way radio profitably, as can fire department officers directing operations of their men inside burning buildings, and tug-boat crews bringing ocean vessels to and from their berths.



Emergency truck of the Toronto Transportation Commission, equipped for two-way frequency-modulation communication. In this installation the radio apparatus is on the roof of the cab and the antenna is alongside the driver

INTERFERENCE—If the two-way low-power sets meet widespread acceptance after the war, it will then be necessary to make some technical provisions for taking care of such inter-station interference in heavily populated areas. Perhaps common courtesy will provide a solution; if voices are heard on a particular frequency, other users will desist from using their radiophones until the first user has completed his conversation. There is greater hope in technical improvements, however, as amateur radio experience in crowded bands indicates that human nature is what it is, and there will always be people who just can't wait their turn.

Ignition interference from automobiles is an important factor in radiophone communication in the high-frequency channels. The effective communication range can be increased considerably if all cars have efficient noise-suppression devices. Meetings of a noise-suppression committee formed of both automobile and radio representatives

have been held, with the goal of setting standards in interference suppression to be followed by all auto manufacturers after the war and incorporated in all new cars. This program will eventually assure police and other radio services of comparative freedom from ignition and generator noise.

IGNITION SYSTEMS—The application of electronics to automotive and aircraft ignition systems already promises solutions to the problems of cross-firing, maintaining spark intensity at high speeds, and reducing sensitivity to loading of the high-tension system by dust and grease deposits on the spark plugs. Many electronic ignition system patents have been granted, and technically electronics can produce today an ignition system that will work perfectly at speeds as high as anyone cares to drive, but economic aspects are definitely against the electronic version as yet. You will still find in your new post-war car the time-honored breaker points, ignition coil, distributor, and spark plugs, collectively serving to step up the storage battery six-volt output to some 10,000 to 15,000 volts and to apply this in correct sequence and timing to individual plugs.

Although superior performance over present ignition systems can be demonstrated, designers of these electronic ignition systems are limited by the fact that the primary power source available is only six volts in the average automobile and rarely more than 24 volts even in aircraft, whereas electron tubes require voltages of the order of hundreds of volts in order to operate with any degree of efficiency. Either rotary- or vibrator-type power packs are needed to provide these high voltages, and instantly the cost goes up. Only when sufficient superior performance can be demonstrated with not more than a moderate increase in price can you expect to lift up the hood of your new car and see one or more electron tubes mounted on the distributor or thereabouts.

SAFETY—In the hands of many people the automobile is a weapon of self-destruction regardless of intent. Witness the 40,000-odd deaths on the highways each year, with no small proportion of them at railroad crossings despite crossing gates, swinging signals, and alarm bells. Consider also the hundreds of thousands who are maimed for life each year because drivers disregard mechanical or electrical warning signals or drive faster than road conditions warrant. These figures approach the casualty figures of war.

Here is where electronics can do a real service to humanity. Here, if people will demand it to the extent of offering to pay a few dollars more for their new cars and for taxes to make highways safer, human lives can be saved.

First, considering only the role of electronics in this accident situation, is control of driving speed. Laws are ineffective because road conditions vary from day to day; a little girl on a sleigh was killed this year because the driver was going 15 miles per hour on slick ice and lost control of his car, yet legally that driver was in the clear. Somebody outside of the driver's seat must determine the safe driving speed at each period of the day for each locality and, with the aid of electronics, force all vehicles to keep within this speed. Technically this is feasible today; it means putting governors on every car, with their adjustments controlled by radio from police radio stations spotted at strategic intervals over the country. But manufacturers in an era of competition will not voluntarily boost their costs by installing such equipment until the people demand it. Each advance in radio has been a result of popular demand, and people likewise have in themselves the power to make highways safer.

Years ago mechanical devices to prevent grade crossing accidents were patented and perfected, and today electronic control could make them doubly safe with the aid of light beams and ever-watchful photoelectric eyes to replace the eyes of neglectful motorists. At least one of these devices raises a barrier in the road that no car can cross—but such devices cost money and the railroads cannot be expected to foot the entire bill. It is up to us, while still living, to make our highways safe for future generations, using electronics whenever and wherever it can do the job better than simple mechanical or electrical devices.

PISTON RINGS

Gaged for Size by Photoelectric Set-Up

To eliminate the human element in production checking of the accuracy of piston rings, a new electronic instrument made by the Sheffield Corporation automatically inspects the trueness of periphery and the width of gap of a specific size of piston ring. Inspection is much faster than present handchecking methods and



Quick gaging of piston rings

the production rate is determined by the speed at which the rings are presented to the gage. The inspection cycle per piece is less than five seconds.

The piston ring to be checked is inserted inside a master ring of correct dimensional quality which is rotated by a power-driven roller. The gaging functions are performed by scanning beams of light directed onto phototubes which energize electronic circuits to illuminate three signal lights.

As the ring revolves, one beam of light is projected on the periphery of the piston ring. A clearance between it and the master ring will result from any out-of-round condition of the piston ring, permitting part of the light beam to fall on the phototube. This actuates a red rejection signal should an excessive amount of light indicate that the piston ring is out-of-round beyond an acceptable point.

A green signal flashes on at the end of one complete revolution if the width of gap is also within tolerance. Another beam of light actuates a yellow signal should the gap be undersize. A third beam of light energizes another circuit to illuminate the red rejection signal should the width of gap be oversize.

SILVERED CRYSTALS

Produced Quickly With Simple Equipment

Quartz crystal manufacturers can now produce a thin conductive silver coating on quartz crystals by simply dipping the crystals into a series of solutions. The work is easy to do and can be accomplished by inexperienced operators. The only equipment required is a few photographer's trays, and clips to hold the crystals. Several hundred crystals may be coated simultaneously, according to Metaplast Company.

Highways Of The Air

Feeder Lines, Serving the Trunk Airlines But Also Providing Short-Haul Aerial Transportation, Have Great Possibilities If Costs are Reduced to Meet Competition of Other Forms of Transportation and if Adequate Facilities are Made Available for Handling Traffic

Is it possible that feeder lines, area airlines, or local airlines, as they have been variously termed, will become the highways of the air, and carry more passengers than the great transcontinental airways? There is much discussion of the question and many people seem to think that feeder lines have great possibilities, provided the right equipment, operational methods, and landing field facilities are forthcoming.

Mr. Neil B. Berboth, summarizing a survey undertaken by Dean C. Smith of Fairchild Engine and Airplane Corporation, calls the term "feeder line" a misnomer. It conveys the idea of small aircraft feeding passengers between trunk airline terminals and smaller off-line cities. A newer and probably sounder conception is one of a nation-wide system serving the trunk lines, but also providing a local interurban air service.

The huge potential markets of the feeder airlines can become an actuality only if cost can be reduced to two cents per passenger mile. In the hearings before the Civil Aeronautics Board the fare rate base is generally given as about five cents a mile; with taxi service and short trips of 50 to 75 miles, this works out to about 6.3 to 7.0 cents a mile! Such a cost would be prohibitive. The chances of success are slim unless over-all travel cost can be reduced to less than 3.5 cents per passenger mile, including airport-to-city transportation.

Here are some of the design factors recommended for lowering the costs of feeder line operation: Convertible cargo and passenger capacity through the use of a movable bulkhead; provision of convenient baggage stowage so that passengers can handle their own luggage, except when this is excessively heavy and cumbersome; provision of roomy cabins set close to the ground, thus eliminating cumbersome loading equipment; use of wide tread landing gear with a steerable nose wheel and powerful brakes to increase maneuverability on the ground; high controllability to reduce air maneuvering time; separate loading doors for cargo compartment and passenger cabin; and provision for quick attachment of fuel hose nozzle underneath the wing, plus rapid gages for measuring the amount of fuel introduced into the tanks.

COST COMPARISON—Granted a passenger load factor of 50 percent and full efficiency of operation, here is what may be expected in comparison with other methods of transportation over a 75-mile stretch:

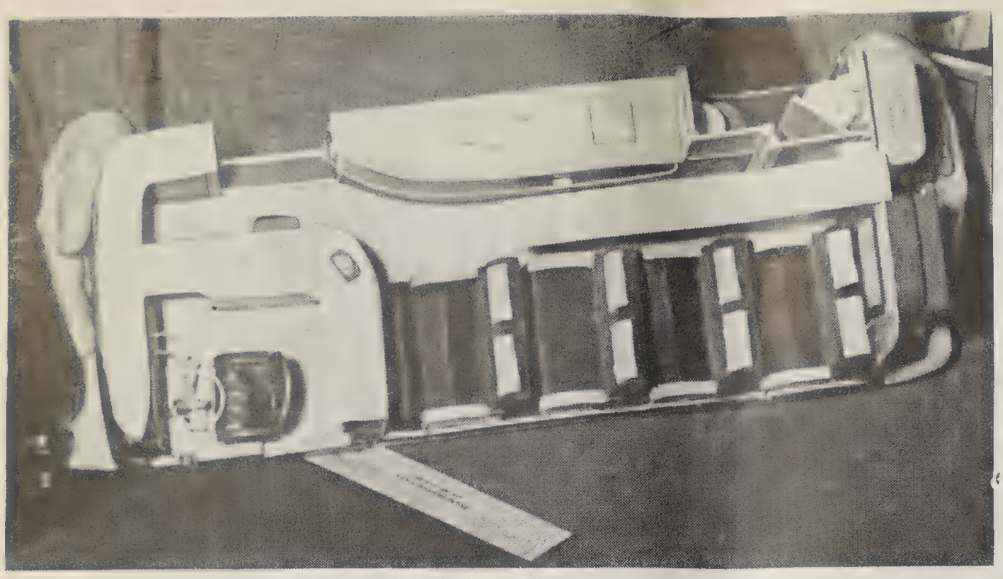
City-to-City	Air	Rail	Bus
elapsed time (including time to airport)	1:15	2:05	2:13
Passenger fare	$1.75	$1.15	$0.95

If this simple table is not over-optimistic, then these figures are quite encouraging. But, of course, besides saving in time and cost because of the design of the airplane, every other opportunity of economizing must be grasped. If care is exercised in all these matters, and airplanes are built which would specifically meet the requirements of local traffic—carry something like eight passengers, baggage, and 1000 pounds of cargo—or, alternatively, twelve passengers and 200 pounds of cargo—then very shortly after the war some 30,000 miles of feeder lines may be expected to be profitably at work, and several hundreds of short-haul aircraft purchased annually from the plane manufacturers.

An experienced motor bus operator, Manfred Burleigh of Great Lakes Greyhound Lines, in an editorial in "Aero Digest," makes a very strong case for the coördination of bus and air equipment in local transportation. He writes: "Local air-bus service, which surface transportation companies propose to inaugurate, would carry passengers, mail, and express, operating on frequent schedules between bus stations in the downtown sections of cities and towns. The air-bus system would be integrated with motor-bus



Photo by U. S. Army Air Forces
A B-23 "picks up" a glider (right) at an Army Air Force training center



A model of the Parks mobile airport station

transportation to bring maximum convenience and economy for the traveling public. Every air-bus terminal or station, whether in small towns or large cities, would be located close-in to the central business district."

HELICOPTERS—All this sounds very reasonable. Perhaps as a surface transportation man, Mr. Burleigh does not give quite enough consideration to the difficulties attendant on the flying of an airplane right into the heart of a city. But probably he meant that helicopters would be the appropriate aerial vehicle, for he goes on to say: "Helicopters, where used, would maintain a minimum scheduled speed of 90 miles per hour, with stops at intervals of 25 to 75 miles depending upon the distribution of population. Direct helicopter connections would be made available to thousands of small communities not financially able to build and maintain the large airports required for fixed wing aircraft. By coördination of motor-bus and air-bus schedules, the residents of small towns and rural areas in between helicopter stops would have air service conveniently accessible to them."

There are many technical difficulties to be overcome, before the helicopter can safely enter such service, but there is a great deal of logic in Mr. Burleigh's remarks.

But if the helicopter is not to be brought into service right away, and if the airplane is still to be the mainstay of even local airlines, what can be done to decrease landing time losses in airline operation, losses which more than compensate for the greater speed of the airplane once it is in the air when short-haul operations are involved?

James G. Ray, vice president of Southwest Airways Company, and himself a pilot of long experience, answers this question. Speeding up the airplane alone is not sufficient because indefinite increase in speed also means prohibitive increase in cost. The answer lies in the intensive study of causes of delay at landing stops. If passenger doors actuated a small folding step, attached to the airplane, passengers could easily climb in and out without the necessity of a loading platform. In refueling a plane, it would be more logical to have a smaller container holding about the amount of gasoline that needs to be serviced into the airplane and mounted on a vehicle similar to a jeep that could be handled much faster than the present tank trucks. It is not unusual to see the engine turn over for quite a few seconds before it starts. At refueling stops it may still be necessary to stop the engine because of fire hazards, but a method should be devised to keep the engine running at all other stops. By taking advantage of these and other improvements, as much as four or five minutes could be saved in the loading and unloading of aircraft.

Dealing with improvements in airport facilities, Mr. Ray has this to say: "Airports as they exist today have become cumbersome and unwieldy in the endeavour to accommodate larger, faster aircraft. The inevitable result of increased landing and take-off speeds has been the expansion of airports in every direction, to the point where they have become so expensive as to be prohibitive for the average small city to establish and maintain. For this problem, too, the area airlines have an efficient and economical solution—flight strips. If possible, these should be laid out parallel to the course of the area line and sufficiently long—at least 2000 feet—to permit landings from either direction without the necessary time-wasting circling, except in the case of strong head winds. The perfect flight strip would be 4000 feet long, enabling planes to land, discharge their passengers or cargo at a point midway down the strip, and then continue their take-off in a continuous directional operation without taxiing delays."

There will also be other developments for the improvement of ground facilities. Here is an idea of a totally different kind, though still related to the same objective, recently presented to the Civil Aeronautics Board by Oliver L. Parks, of Parks Air College. It involves a mobile airport station that looks like a trolley bus and performs like a station wagon. It is designed to drive right up alongside an airplane where it stops, deliver and take off passengers, mail, and cargo —in short, to serve all the requirements of an airport terminal building and more. This would be an excellent device to coördinate with the flight strip, and certainly of interest to the feeder-line operator. Built-in features will include everything from a ticket-sales counter to toilet





Left: Martin's high-wing 30-passenger plane. Right: Interior accommodations of a transport plane with movable partitions by means of which cargo space in the forward compartment can be expanded or contracted. Note provisions for securing odd-shaped packages

facilities. All will be housed in a vehicle 8 feet wide, some 22 or more feet in length, and 9 to 10 feet in height.

PLANES—Engineers of the Glenn L. Martin Company have designed a 30-passenger plane for short-haul operation. The plane can be either low or high wing. There is so much discussion regarding the position of the wing, and there are so many good arguments on either side, that Martin is quite right in providing alternatives. The high wing furnishes better passenger vision, greater ease of loading and unloading, and reduced ground time. On the other hand, the low-wing design provides a shorter landing gear and reduced empty weight. In both cases a tricycle landing gear is provided for convenience in loading and unloading and to keep the floor level at all times. Either Wright or Pratt and Whitney engines can be employed.

The models are designed to operate over a 500 mile range, at a cruising speed of 250 miles an hour, or nearly 50 percent greater than that of present-day airliners.

There are included in the Martin design two large hatches—one forward and one aft—at lower than truck height, which is significant. There will also be available a moveable bulkhead or wall to separate cargo and passenger compartments. Thus the size of each compartment can be varied according to the number of passengers and amount of cargo demanded for each trip and, with standard cargo tie-down fittings, a complete conversion will be made in 20 minutes or less. As an added convenience for passengers, a compartment for hand luggage is included just inside the entrance so that air travelers can bring their own bags aboard and have them available throughout the flight.

The proposed Douglas "Skybus" probably comes closer to the requirements of the local airline than does the excellent Martin proposal. This design involves a high-wing, twin-engine, all metal monoplane with tricycle landing gear. High pay load will be provided with a maximum of 24 passengers; extreme maneuverability in the air and on the ground, ability to land and take off in small airports, and low landing speed are among important features. Further, two wide, truck-bed-level doors, an adjustable bulkhead in the cabin, large baggage racks, and many other new features assure quick and easy loading. The engines are of 700 horsepower each.

Any discussion of feeder airlines must at least mention the system of air pick-up used so successfully by All American Aviation for mail and cargo, and now adapted to glider and human pick-up. This system of pick-up has peculiar significance for the small community, and greatly increases the chances of even the smallest communities securing the maximum in air service. Further, there is not the slightest doubt that, should it be found practicable to employ gliders in air cargo transportation, the pick-up system will be completely ready for service.

If the new highways of the air—the feeder lines—can be made successful through inventiveness or the application of mechanical ingenuity, their operators can certainly be confident of receiving such help.

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FASTEST FLIGHT

Achieved by New Jet-Propelled Plane

THE SHOOTING STAR, newest American jet-propelled fighting plane, produced with the aid of the Army Technical Service Command at Wright Field, General Electric Company, Lockheed, and the British RAF, has aroused considerable interest.

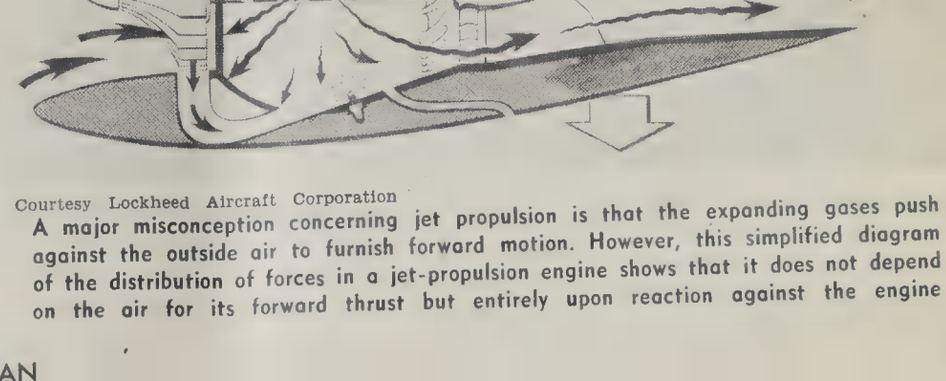
Streamlined ducts in the leading edge of the wing lead air to the engine where a high-speed fan forces the air into it at high compression. From the compressor, the air passes into the combustion chamber where it is mixed with fuel injected at high pressure. A continuous explosion occurs in this combustion chamber, heating the gases to an extremely high temperature and causing them to expand violently. The exploded mixture under great pressure can move only in one direction —toward the back of the airplane.

Once the engine is started, no ignition system is necessary. A small metal plug protruding into the combustion chamber heats red hot in the first few seconds of operation, and thereafter serves to ignite the mixture of air and fuel as it is introduced. For the initial starting, spark plugs are used.

From the combustion chamber, the hot gases pass rearward through a gas turbine. The turbine, connected by a shaft to the compressor fan, supplies the power necessary for the intake and compression of air.

The basic simplicity of jet engines may lead to rapid production for military purposes now that workable engines have been developed. Many of the problems of reciprocating engines—cooling, complex electrical systems, gear drives, and the like—are all eliminated. For fuel, the General Electric's engine uses kerosene, which is preferable to gasoline because it provides somewhat more Btu's per pound and per gallon. Thus the dangers of handling high octane gas are eliminated. While no definite design or performance information is given, the Air Force permits it to be known that these planes are faster than anything that Japan or Germany have flown, including the tailless Messerschmidt 163 Rocket Interceptor. Production is well under way.

Armament of the Shooting Star is located in the nose for most effective concentration of firepower. The fuselage is lacquered to a high polish of indefinite color and, with a minimum of air resistance, slips through the skies like an apparition of death. The wing is refined and is a brand-new type, with a knife-like leading edge, to avoid the problems generally encountered at or near the speed of sound. Streamlined air-intake ducts nestle on each side of the fuselage just forward of the leading edge of the wing. Rate of climb and angle of climb at high speeds are said to be superlative. The cabin is pressurized.



Courtesy Lockheed Aircraft Corporation

A major misconception concerning jet propulsion is that the expanding gases push against the outside air to furnish forward motion. However, this simplified diagram of the distribution of forces in a jet-propulsion engine shows that it does not depend on the air for its forward thrust but entirely upon reaction against the engine

Automotive Rubber

Forgetting for the Moment Today's Pressing Question of Tires, Consideration is Given to the Place of Synthetic Rubber in Mechanical Parts for Post-War Vehicles. Temperatures Encountered in Operation, Stresses Imposed, and Other Factors Must Be Known if the Designer is to Take Full Advantage of the Mechanical Qualities of the Synthetics

SYNTHETIC rubber is here to stay for mechanical parts on automobiles, trucks, tractors, and airplanes—not as a rubber substitute but as an essential engineering material. Natural rubber will never again be used for hundreds of different mechanical parts, in which synthetic rubbers are already outperforming it. The development of synthetic rubber is in its infancy and we can look forward in the immediate post-war years to further improvement in compounding technique and to the development of new synthetic elastomers.

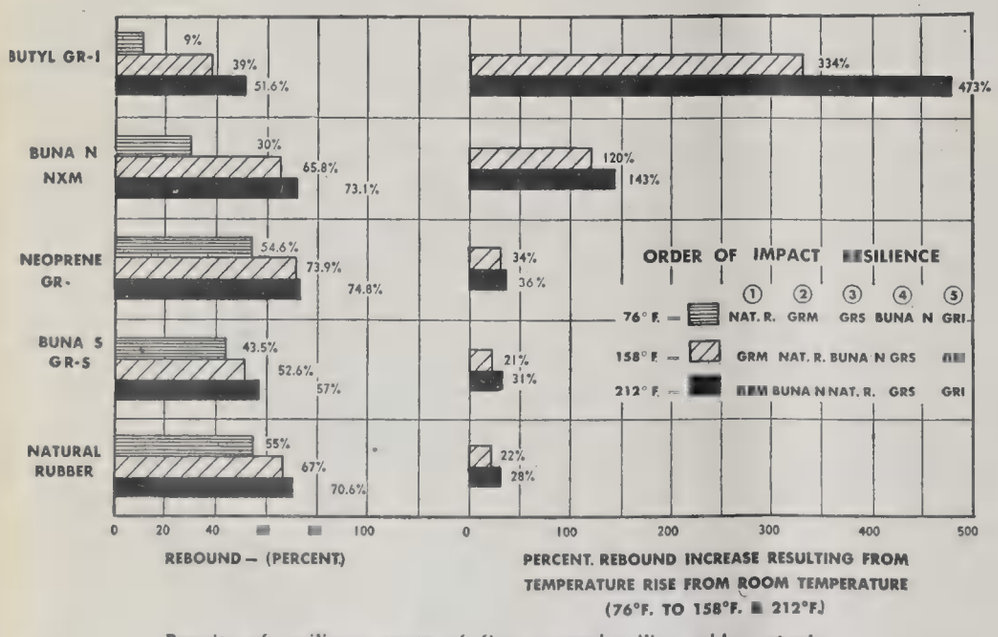
All synthetic rubbers (that is, synthetic elastomers) are tailor-made, long chain molecular arrangements, high polymers with molecular weights ranging as high as several hundred thousand. They are products of polymerization phenomena, and the wonders of this mechanism have just begun to be realized. While no one of the tailor-made elastomers possesses all of the properties wanted today, several of them have already made natural rubber take a back seat in certain specific applications. With the rapid development in this field, entirely new synthetic elastomers will undoubtedly possess properties greatly superior to those now in production. The rubber industry should then be able to give vehicle manufacturers materials with tailored-to-order physical properties for specific applications.

PROPERTIES—The synthetics possess amazing properties. They provide wonderful resistance to oils, gasolines, solvents, chemicals, gases, ozone, sunlight, flame, heat, cold, and flexing, that enable us to build mechanical parts which are giving unbelievable performance in planes, tanks, amphibian units, and sea-operating craft. In fact, synthetics permit the use of rubber-like materials where natural rubber could never be considered.

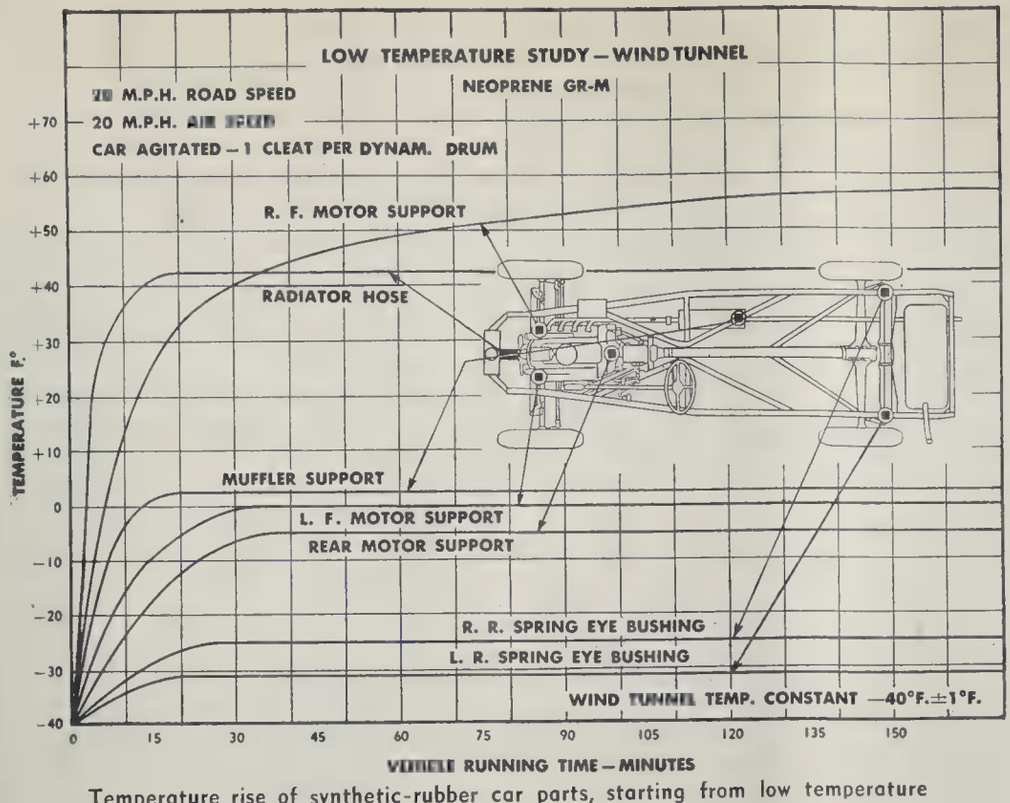
Information generally available on synthetic rubbers has been limited to room temperature, conventional physical properties, and static studies such as ultimate tensile strength, elongation at rupture, and compression set. But highly functional synthetic rubber parts demand of designing engineers full knowledge of the synthetic elastomer compounds they plan to use at operating temperatures which seldom are room temperature. A few of these men have been thoroughly disappointed with some synthetic rubber compounds which give inferior performance in designs based on knowledge of the properties of natural rubber. Any changeover is not so simple as just specifying the use of synthetic instead of natural rubber; the properties of synthetic rubbers are vastly different from natural rubber over a range of conditions. Often alterations of design and certainly of dimensions are necessary for success with synthetic.

Some of the synthetic rubber compounds are superior to natural rubber compounds for mechanical rubber goods parts. A goodly number of the properties of any synthetic rubber stock depend on the compounding ingredients and the compounding technique. Lack of success may not be the fault of a particular basic synthetic elastomer. Much can be accomplished by correct compounding. As an illustration, a GR-S compound showed flexing fatigue failure after 9000 cycles; however, the same elastomer with an entirely different compounding technique gave a flexing life up to 99,000 cycles, an improvement of 1000 percent. Synthetic elastomers are much more sensitive

Based on abstracts from a paper by Ellwood F. Riesing, Chief Automotive Engineer, Firestone Industrial Products Company, presented at the War Engineering-Annual Meeting of the Society of Automotive Engineers. Final original paper copyright 1945 by Firestone Industrial Products Company.



Results of resiliency tests of five general-utility rubber stocks



Temperature rise of synthetic-rubber car parts, starting from low temperature

to differences in compounding than is natural rubber.

In pre-war years, we were not too concerned with the effect of temperature on the properties of natural rubber. Temperature greatly changes properties of both natural and synthetic rubber compounds but the influence which temperature has on the properties of the synthetic rubbers available today is much more pronounced than on those of natural rubber; therefore the designing engineer must not only consider the temperature range in which his designs are to function, but must know at what temperatures the maximum and minimum stress occurs in the synthetic rubber parts under consideration.

The conventional method of specifying properties for mechanical rubber goods compounds today is the same as it was 30 years ago. Tensile values are still expressed in pounds per square inch at rupture, tested at room temperature. Elongations also are still expressed at rupture at room temperature.

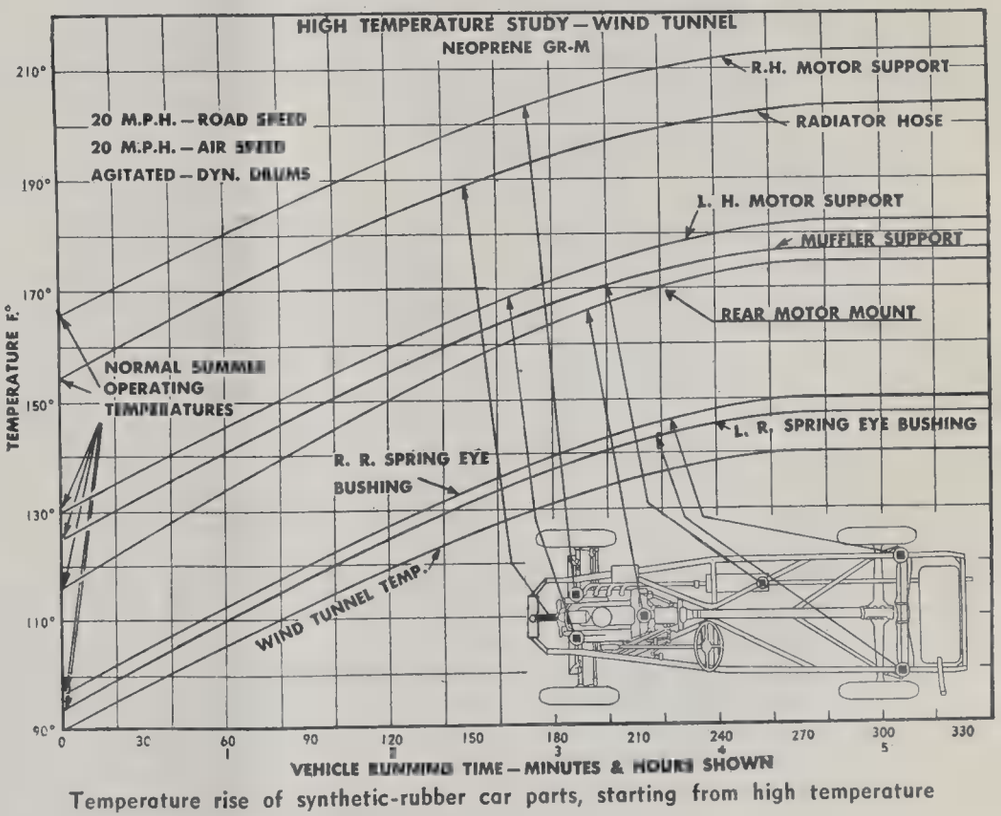
Actually, not one of the highly functional rubber parts of automobiles, trucks, tractors, or airplanes operates at room temperature only. Consider, for example, the operating temperatures of motor supports, fan belts, muffler insulators, water pump seals, radiator hose, engine throttle insulators, and other parts. Hence the conventional room-temperature property studies alone do not permit complete evaluation of the synthetic elastomers commercially available today. Careful measurements of the operating temperatures of various highly functional automotive mechanical rubber parts recently revealed some astounding data. Automobile motor mountings, as an illustration, on vehicles operating in hot southern states build up temperatures of 150 to 180 degrees, Fahrenheit. On desert runs temperatures may rise as high as 214 degrees, Fahrenheit.

STRENGTH—Tensile pulls and their respective elongation, as has been noted, are expressed at rupture at room temperature. However, all highly functional resilient insulator parts have their movements limited mechanically, and it is therefore not logical to study only ultimate tensile values. None of the vibration isolation or insulator devices employed today on vehicles allows movement much beyond 100 percent elongation at operating temperatures. Most of them function at 15 to 30 percent elongation, so why study tensile values at rupture at room temperature where elongations may run to 800 percent or more? Tension curves for synthetic and natural rubber compounds are not linear and therefore show amazingly different tension modulus values in the lower elongation ranges encountered under actual working conditions.

Conventional tensile determinations at rupture would condemn some of the synthetic elastomers that are today actually giving amazing performance. Some of these are definitely giving better performance than natural rubber compounds.

Pre-war natural rubber (50 durometer stock) has the same tension modulus at 150 percent elongation as does neoprene (GR-M) and Buna S (GR-S); however, a raise in temperature to 158 and to 212 degrees, Fahrenheit, stiffens the modulus of the natural rubber and the Buna S (GR-S) in this low-strain actual operating range, but does not noticeably change the tension modulus of the neoprene (GR-M) compound. The stability of this neoprene compound is therefore better suited and more ideal for motor mountings or other parts operating under these indicated temperature conditions. Tension modulus studies at low temperatures (0, −25, and −40 degrees, Fahrenheit) bring out the low-temperature sensitivity of the general-utility synthetic elastomers.

BOUNCE—Resilience values of compounds at specified temperatures



Temperature rise of synthetic-rubber car parts, starting from high temperature

are essential in any design of impact-absorbing devices, such as rubber springs, spring stabilizer insulators, frame insulators, axle bumpers, shock absorber insulators, engine stabilizers, instrument mountings, and aircraft landing gear parts.

Resilience can be determined by the rebound of a steel ball, permitting comparisons between synthetic elastomers and natural rubber compounds. "Impact resilience" is expressed by dividing the first rebound height by the distance of the free fall.

Butyl rubber behaves remarkably in this test. At room temperature it has a rebound of only 9 percent, but after the compound has been heated to 212 degrees, Fahrenheit, has a value of 51.6 percent. This rebound at the boiling point of water is greater than Buna-S rebound at room temperature. The neoprene compound is approximately equal to the natural rubber at room temperature and exceeds the rebound of the natural rubber when both are heated to 158 degrees, Fahrenheit. The rebound of neoprene compound also exceeds that of the natural rubber compound when both are heated to 212 degrees, Fahrenheit.

The Buna N (Butaprene-NXM), a butadiene acrylonitrile co-polymer, likewise shows greater rebound than natural rubber at 212 degrees, Fahrenheit. The butadiene acrylonitrile copolymers have a high resilience at elevated temperatures, but comparatively poor resilient properties at low temperatures. Butyl (GR-I) shows the greatest increase in rebound resilience of all the elastomers resulting from the temperature rise from room temperature to 212 degrees, Fahrenheit —that of 473 percent, compared to 28 percent for natural rubber. Certainly there should be applications where this property of Butyl can be utilized to its fullest extent.

At extremely low temperatures where rubber-like materials must be used, one or more of the present-day synthetic elastomers will not only out-perform natural rubber, but will also have the desirable feature of not becoming brittle at temperatures substantially below the brittle point of natural rubber. Some of the oil-resistant synthetics have lower brittle points than natural rubber. Emulsion polymerized polybutadiene compounds not only will excel natural rubber in having an extremely low brittle-point temperature (—100 degrees, Fahrenheit), but will also out-perform natural rubber by being flexible at low temperatures. The comparatively new technique of compounding synthetic rubbers with low-temperature depressing plasticizers for extremely low-temperature operating conditions is becoming increasingly important to the design engineer, especially for the aircraft industries. Natural rubber does not lend itself, as do synthetic elastomers, to compounding with large amounts of low-temperature depressing plasticizers and modifiers, which cause too serious a decrease in mechanical properties.

For resistance to ultra-violet rays, ozone, acid, and gas diffusion, one or more of the synthetic rubbers show up vastly superior to natural rubber. Under conditions of direct sunlight, ultra-violet radiation, and ozone as generated by corona electrical discharge and by other means, natural rubber deteriorates very rapidly. Some of the synthetic elastomers are better than natural rubber by several thousand percent in life under these conditions. Resistance to ozone and corona are all-important for ignition distributor gaskets, distributor harness boots, ignition wire covering, sun-exposed windshield wiper blades, and sun-exposed windshield and window seals.

In intimate contact with oils, natural rubber is an inferior material and can not possibly give satisfactory performance, whereas several of the synthetic elastomers have been giving outstanding performances over long time intervals.

The future possibilities of synthetic rubber-like elastomers as engineering materials are practically unlimited. Some special compounds of emulsion-polymerized polybutadiene, not on the market today, may prove to be the long-awaited material for use in special refrigeration equipment. In such applications natural rubber could never be used as it becomes as brittle as glass at temperatures below —68 degrees, Fahrenheit.

NEW SYNTHETICS—Butyl is the newest of the present-day commercially available synthetics, and has real possibilities. The tremendous improvement in resilience of Butyl compounds resulting from rise in temperature from room temperature to 212 degrees, Fahrenheit, should make this synthetic the answer to numerous application problems where this property is desired.

Greater improvements in Buna-S copolymers can be expected because of the large number of variations possible in butadiene and styrene ratios. This is true also of the Buna-N group where startling results can be anticipated from multi-polymerization of the butadiene with various other materials, plus blending with various plastics which would withstand temperature variations from —40 to +350 degrees, Fahrenheit, without charring or violatilizing and without shrinking or becoming brittle and having the least tendency to absorb water. Silicone rubber has all of these properties and should prove to be the engineering material for dozens of special-purpose applications.

Dichlorostyrene-butadiene copolymers likewise recently have been announced. They should also prove very desirable engineering materials because of their compounded physical properties being a combination of those normally associated with natural rubber.

One or more of the present-day synthetics are superior to natural rubber in a vast amount of different physical properties. With further developments in synthetics, new materials for engineering applications may be expected to give performance not even approached by any other engineering materials used in the past or available at present.

ALCOHOL FROM FARMS

Made More Economical by Use of Mobile Units

IMPROVED economies in the output of alcohol from farm products and wastes are expected in the post-war period by the production of alcohol on a train of five railroad cars fitted out as a mobile plant. High freight charges on raw material and the need for large quantities for continuous operation will be obviated by taking the mobile plant to the raw material source. The process used employs many recent improvements which speed up the operation and allow a plant of economical capacity to be mounted on freight cars.

Although economies in manufacturing costs can be effected by the new mobile plant, the quantity of alcohol producible from a bushel of corn is unchanged and limits the possibility of converting farm products economically into motor fuel, when the farmer is paid a reasonable price for his product. The new mobile unit is expected to cheapen farm-produced alcohol by reducing production expenses as well as by obtaining its raw material at the most advantageous price directly at the farm.

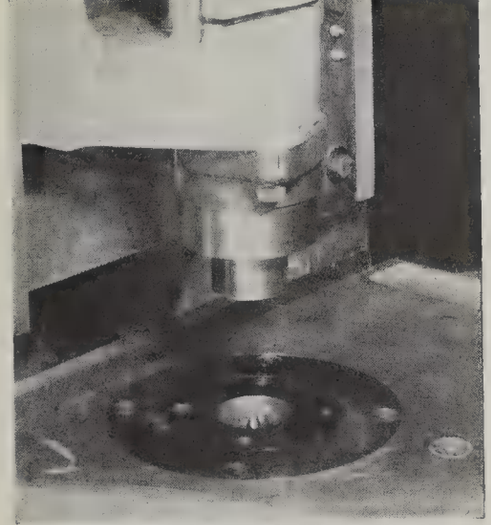
Miracle Or Mirage?

Powder Metallurgy, an Older Art than Many Realize, Can Thank the Automotive Industries for Much of its Recent Expansion. Will this Growth Continue or Will the "Modern Miracle" Prove to be a Mirage?

ONE of the largest question-marks facing industry today is the future of powder metallurgy, that simultaneously ultra-modern and old-as-the-hills metal-working process that can circumvent both metal-melting and machining to produce precision parts at mass-production rates. Large companies and small are either actively engaged in or interested in the use of metal powders, with scores of others wondering if they too, shouldn't be!

The automotive industries share with the manufacturers of electrical products the credit for most of the outstanding powder metallurgy developments in recent years. Their example has been followed by other industries, and out of this has emerged a well-integrated "powder metallurgy" industry.

In view of this expansion, widespread applicability, and growing prominence of powder metallurgy, many manufacturers are today asking themselves: "Is this something I should be using? Is there a place for powder metallurgy parts in my products, or, indeed, should I even enter into the production of powder or powder-parts, either for our own use or for sale outside?" The answers to these questions must be based in any case on a clear understanding of what powder metallurgy is and what it can do.



Courtesy Kux Machine Company

Punch and die on a mechanical press that molds powder metallurgy parts

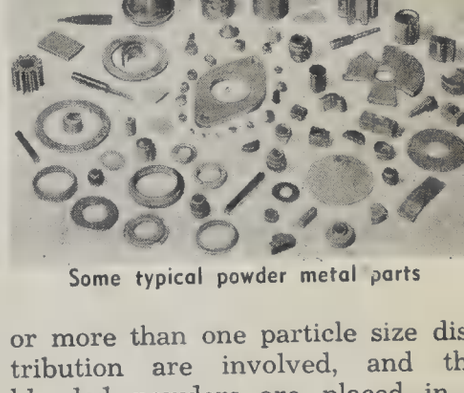
WHAT IT IS—The term "powder metallurgy" most accurately covers the whole field of the production and use of metal powders, but here emphasis shall be placed on that phase represented by the manufacture of parts and solid products by pressing metal powders to shape in a die or mold, heating or "sintering" the pressed part (called a "briquette") to strengthen and consolidate it, and then (in many cases) subjecting it to a final coining or sizing operation to obtain closest dimensional accuracy.

For each type of product to be pressed and sintered, the powders must be carefully chosen for purity, size, size distribution, flow characteristics, "apparent density," and pressing characteristics. Powders that are not clean with respect to individual particle surfaces may not consolidate properly; too hard a powder may be expensive to press; incorrect particle size distribution may result in poor packing, "bridging," inability to achieve the exact density or porosity desired in the finished part, and so forth. The "apparent density" of a powder (the weight in grams of one cubic centimeter of the powder) is a vital factor since it affects the amount of powder required to produce a briquette of a given size, the blendability of the powders when they are mixed, and so on.

POWDER COSTS—Metal powders are quite expensive, as raw materials go. A standard grade of copper powder costs about 20 cents a pound, while iron powder, on which any future expansion of powder metallurgy as a competitive parts-fabricating method clearly depends, is priced between 10 cents and nearly one dollar a pound for various grades. But an ear to the ground can occasionally detect rumblings that indicate a possible early lowering of price and an increase in the amount of inexpensive iron powder available.

After selection and grading, powders are sent to a mixing or blending machine, if more than one meta

Courtesy Kux Machine Company



Some typical powder metal parts

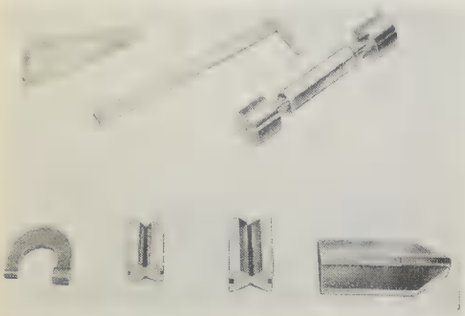
or more than one particle size distribution are involved, and the blended powders are placed in a mold and pressed in a mechanical or hydraulic press.

In recent years press sizes and pressures have increased considerably, with a consequent increase in either the maximum cross-section area of parts that can be pressed, in the density and mechanical properties of the pressed products. Thus two of the chief classic limitations of powder metallurgy parts—the characteristically small size and the relatively low strength—are being successfully attacked and may in time be much less important than formerly.

The "green" (pressed but not sintered) briquettes are next consolidated and strengthened by heating to a suitable temperature, usually in an inert or reducing atmosphere and occasionally in a vacuum. The temperatures employed are approximately two thirds of the melting point of the metal or alloy being

sintered, although some sintering temperatures approach the melting point itself.

The sintering operation, while necessary to obtain product strengths comparable to those of conventionally cast or wrought metals, introduces problems of its own, especially through the dimensional changes (usually shrinkage) that occur in the process. Thus it is often desirable to control final size



Through the powder-metallurgy process, these precision gages and die parts are made from iron powders by Chrysler Corporation's Amplex Division

very accurately or to improve surface finish by repressing or coining the part in a final sizing operation. This practice is now widely used, especially for parts whose dimensional tolerances must be held to .001 inch or closer.

Another auxiliary operation of considerable importance is the impregnation of porous parts or materials with a pore-filling constituent, the best examples of this being the impregnation of porous bronze or iron bearings with oil to make them "self-lubricating" and the absorption of molten copper into porous tungsten to produce tungsten-copper electrical contacts.

SPECIAL EFFECTS — From this necessarily brief description of the powder metallurgy process it is evident that it can achieve certain special effects or structures that would be difficult or impossible to obtain otherwise. It can produce materials or parts of controlled porosity, as in the porous or self-lubricating bearing and filters or screens. It can produce solid metals whose melting points are prohibitively high for the usual melting and casting practice, such as, for example, tungsten or tantalum products.

In addition, mixtures of non-alloyable or immiscible-by-melting metal combinations like copper and lead for copper-lead bearings, or tungsten carbide and cobalt for carbide tools, can be manufactured by powder metallurgy. It permits the production of parts and materials in which the ingredients retain their separate characteristics; the heat conductivity of copper, the running properties of lead, and the friction-producing characteristics of emery in the sintered copper-lead-emery clutch facing is a good example of this.

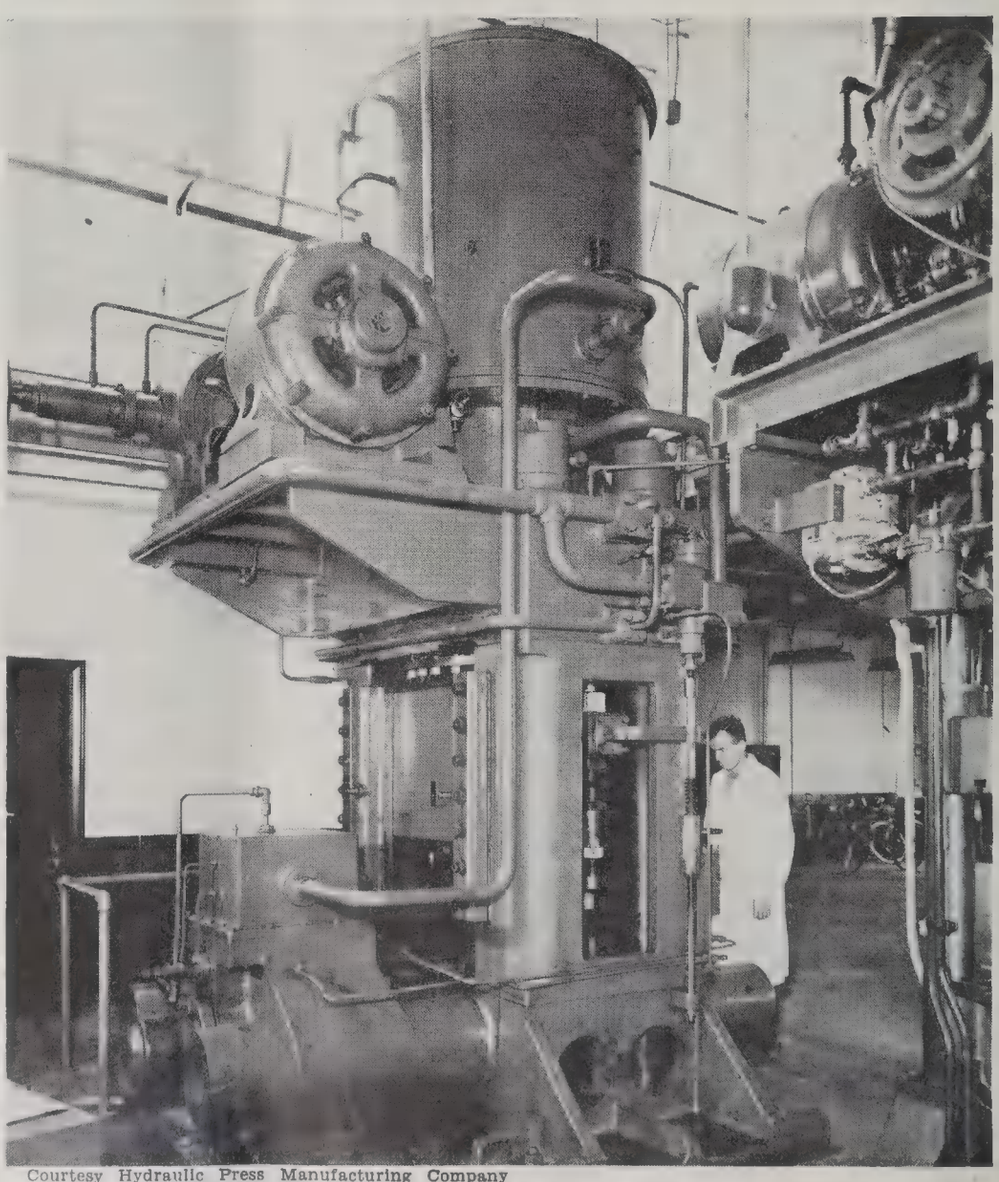
Where ultra-high purity of the material is vital, as in refractory metal products for electronic tube service, magnetic cores for radio and telephone use, and so on, powder metallurgy avoids the possibility of contamination that is usually present in melting and casting operations. Again, powder metallurgy is especially useful for materials like Alnico magnets that are virtually impossible to machine to final dimensions.

COMPETITIVE FEATURES — All these are the "specialty" advantages of powder metallurgy which have led to its use for literally millions of parts that could not be made commercially by other methods. But what of the "competitive" features of powder metallurgy that permit it to replace machining or forging or stamping or casting for certain mechanical parts, with evident cost or production advantages, and what of its disadvantages and limitations in these respects? These features are important, for on them may depend the answers to the question about powder metallurgy's future.

In the first place, powder metallurgy is fast; production rates up to 1600 pieces per hour are common and much higher rates (even up to 500 per minute) have occasionally been reported. There is virtually no material waste in the process because of the absence of machining, casting sprues, forging flash, and the like. In many cases overall economy may be considerable through the automatic, high-production, low labor-cost nature of the process and the elimination of many operations often required to make the parts by machining.

Close dimensional tolerances (about ±0.001 inch on parts up to two inches long or wide) can be held, with 0.0005 inch available at extra cost, for special work on small parts. Larger parts can be held to ±0.002 inch tolerances.

The chief competitive disadvantages of powder metallurgy are the high cost of the powders in comparison with the raw material for other metal-working methods, and moderately high cost of dies, and the relatively low mechanical strengths



Courtesy Hydraulic Press Manufacturing Company

A hydraulic press for briquetting tungsten bars

of powder metallurgy products. A rather imposing set of design limitations (avoidance of sharp corners, abrupt changes in section thickness, undercuts and re-entrant angles, parts that are too long for their cross-section, and so on) not only restrict the complexity and variety of products, but also require the use of part and die designers with considerable experience in this field.

Part sizes, too, are definitely limited by press capacities. And, finally, powder metallurgy is economically best suited to mass-production requirements, although a few cases are on record of economical production of parts in lots of less than 500.

The competitive advantages of powder metallurgy have outweighed its disadvantages in comparison with other methods for scores of machinery and ordnance parts, made chiefly from iron, brass, or bronze powders. A familiar example is a small spur gear for automobile oil pumps, formerly made by machining cast-iron blanks. When pressed from powdered iron, enough material (normally wasted in machining out the teeth) was saved to more than offset the higher raw-material cost of the powder; indeed, the final cost of the powder metallurgy gear was only 40 percent of that of the cast-and-machined gear, and the surface properties of the sintered gear were superior.

Gears, cams, ratchets, door-locks, levers, splined parts, zipper die molds, trigger components, and dozens of other parts made from metal powders have justified the economy of their manufacture and proved the applicability of powder metallurgy during the war. But it is still far from a panacea for the cure of all production problems.

LOOKING FORWARD—Actually the best thinking in the industry runs something like this: Powder metallurgy's basic importance and major applications still rest largely on "specialty" uses — self-lubricating bearings, electrical contacts, cemented carbides, filters, friction materials, refractory metals, motor brushes, and so on, that can be made only by this method.

The use of powder metallurgy for making machinery parts will gradually increase and the rate of increase will be accelerated if and as a lower cost, good-pressing iron powder becomes available in large quantities, much larger presses than those now in use are built, and the mechanical properties of pressed and sintered parts are considerably improved. But it will be at least a few years before the expansion in this phase reaches "boom" proportions, and it will *never* reach the stage where powder metallurgy will be a menace to the forging, casting, or machine tool industries.

For those curious about the place of powder metallurgy in their lives the best answer therefore seems to be — investigate powder metallurgy and powder metal parts for your products wherever possible, especially with the help of an experienced powder fabricator. Such parts may save you time, money, or materials. But unless you have a distinct economic or raw material or technical advantage, don't enter the field of powder or parts manufacture in competition with the established and experienced producers, for it is one field that is fast approaching saturation.



DEEP DRAWING

Now Accomplished With ½-Inch Magnesium Sheets

Most of the deep drawing and forming work on magnesium alloys has been done with light and medium-gage sheet—0.125-inch gage and lighter—and they have usually been formed through only one or two press operations. The Worcester Pressed Steel Company, however, has developed a technique of deep drawing magnesium domes 10 inches wide and 11 inches deep from magnesium alloy sheet ½-inch thick.

The process involves hot drawing at about 600 degrees, Fahrenheit, in a double-action draw press, "ironing" the sidewall to reduce its thickness, and hot forming (piercing, indenting, upsetting, and sizing) the dome to final size and shape. The material and method replace cold-drawn aluminum previously used for this part.

METAL POWDERS

Pose Problems for Post-War Use

With all the interest in powder metallurgy and its post-war possibilities as a method for fabricating machine parts, it is well to remember that the metal powders now in largest production are used for an entirely different purpose. The amount of aluminum and magnesium powder used in bombs and flares represents far and away the largest metal-powder application in the war; actually, the annual tonnage production of aluminum powder alone (mostly for pyrotechnic use) is now greater than the corresponding pre-war figure for aluminum metal in all forms.

This suggests a tremendously expanded post-war use of aluminum paints and printing inks, thermit welding, aerated concrete, and other established peace-time applications of aluminum powder. But who knows how we will use our great magnesium-powder production capacity when the war is over?

MAGNETIC ALLOY

Exhibits Powerful Permanent Magnetism

A comparatively new permanent magnet alloy called Alnico No. 5, has been found to have about double the residual magnetism of any Alnico previously made.

This alloy has had many applications for ordnance equipment. Its composition is approximately 8 percent aluminum, 14 percent nickel, 24 percent cobalt, 3 percent copper, and 51 percent iron. To bring out the maximum magnetic properties, a special heat treatment is required which consists in heating to 2420 degrees, Fahrenheit, and cooling in a magnetic field.

VACUUM CASTING

Introduces New Metal-Working Technique

The growing use of vacuum and low pressures in metal-working processes is interestingly exemplified in the technique developed by Machlett Laboratories, X-ray tube manufacturers, for casting copper anodes for X-ray tubes.

The anodes are from three to five inches long and up to 2⅝ inches in diameter, with a tungsten insert cast on for the target. Graphite molds, machined to size and shape, are used, the mold serving as a graphite crucible with the copper ingot so positioned that when molten it will run down into the mold.

Melting is accomplished by induction heating. The furnace itself is made of glass and consists of a quartz cylinder inside a glass cylinder with cooling water circulating between them. The graphite mold with its copper ingot ready is suspended inside the furnace; the latter is evacuated by means of oil diffusion pumps to 0.00001mm of mercury. The vacuum is maintained during the melting and cooling of the copper casting.

A series of eight furnaces is employed to give semi-continuous production—one casting every 25 minutes. The technique, which provides clean, oxide-free, gas-free, highly pure castings, can be applied to most metals.

The Jeep' Post-War

Improvements and Changes in the Famous Military Vehicle Have Already Made it More Useful for Heavy Work in Civilian Life. Retaining the Famous Four-Wheel Drive, the New Jeep has a Transmission Adapted to Many Uses and a Re-Designed Combustion Chamber

OFTEN asked is the question: "What about the 'Jeep' in the post-war period?" And now the answer can be definitely given: "There already is a post-war Jeep."

The post-war Jeep is modestly described by Willys-Overland officials as "the first vehicle in history to combine successfully the basic functions of the light truck, tractor, mobile power unit, and passenger conveyance."

Although it resembles the standard military Jeep, and embodies the same automotive concept which made this car the most versatile weapon in the allied arsenal, the post-war Jeep presents to the public special values of its own for the farm, factory, railroad yards, mines,



Jeep can deliver a crate of eggs or a load of baled hay with equal ease

oil fields, lumber camps, and other peace-time operations.

The concept represented by the military Jeep—a balance of power, weight, size, four-wheel drive, dependability, and ruggedness—has been adapted for peace-time service to mankind around the clock, around the year, and around the world.

POWER TAKE-OFF—Most important differences between the military Jeep and the post-war Jeep are the special power take-off which can be used with a spline shaft for direct power or with a belt pulley, thus making it possible to delegate up to 30 horsepower to anything from a buzz saw to a thresher; and the changed gear ratios in the transmission, transfer case, and axles. This latter revision results in maximum efficiency while operating at a necessary farm pace of three to seven and a half miles an hour. A gear ratio is provided to give a road speed of 60 miles per hour. These developments assure long life for the post-war Jeep.

The power take-off, as far as the Jeep is concerned, is something brand new. The post-war Jeep is engineered and designed to take advantage of mobile Jeep power to carry it over difficult terrain to the job; to adapt it to a long list of stationary tasks; to pull heavy equipment over the highways at a rapid rate; and to perform tractor-type jobs on and off the highways with speed and efficiency.

In the Jeep's new transmission, there are wider gears of more suitable ratios, better lubrication, and larger bearings, which means an unusual combination of power and speed. There is a higher oil level in the engine and greater oil capacity.

IMPROVEMENTS—Other differences between the military Jeep and the post-war Jeep are:

1. A new combustion chamber in which altered dimensions in the cylinder head and combustion chamber, perfected in the light of the newest engineering knowledge, increase the power of the post-war Jeep.

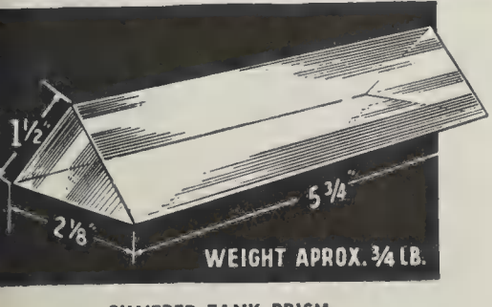
2. A radiator shroud provides more effective cooling for continued low-gear driving on the farm and in other highly-demanding work.

3. A larger clutch permits easy starting with increased loads. Once engaged, the capacity of the clutch to transfer the full torque of the engine makes only a nominal difference, but in the act of starting, additional stress is necessarily put upon it, and the change obviates any



Tree spraying, using a Jeep to pull tank and provide pressure

TERRIFIC BARGAINS IN WAR SURPLUS LENSES AND PRISMS



SILVERED TANK PRISM
0-45-45 degree, 5¾" long, 2⅛" wide, finely ground and polished. Would normally retail from $24 to $30 each.
Stock #3004-S ..... $2.00 each Postpaid
(Illustrated booklet on Prisms included FREE)
FOUR SILVERED TANK PRISMS—SPECIAL $7.00
Postpaid . . . This is the most sensational bargain we have ever been able to offer.

TANK PRISMS

90-45-45 degree prisms of huge size—5¾" long, 2⅛" wide, finely ground and polished. Used to build a Periscope . . . excellent also for experiments, classroom demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachments, photometer cube, range finder, etc. Normally, these Prisms would retail from $24 to $30 each.

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked.

YOU CAN EASILY MAKE

Telescopes, Magnifiers, Photographic Gadgets and Hundreds of Experiments with these low Cost Lenses.

To translate millimeter measurements: 25.4 mm. equals one inch.

8 MM. MOVIE PROJECTING LENS SET — Consists of 2 Achromatic Lenses, diam. 15 mm. and F.L. when combined of approx. one inch. Each lens has the new magnesium fluride low reflection coating.
Stock #4011-S ..... $1.40 Postpaid

POLAROID — Suitable for Experimentation. Consist 2 discs — 2½" diam. Some imperfections in glass.
Stock #622-S ..... $1.00 Postpaid

12-POWER COLOR CORRECTED MAGNIFIER SET — Consists of two 15 mm. diam. magnesium fluride low reflection coated Achromatic Lenses and section of metal tubing for mount.
Stock #1029-S ..... $1.50 Postpaid

RETICLE SET . . . Five assorted, finely engraved Reticles from U. S. Gunsights. An unusual group . . . just like those assisting our gunners to train sights on Tokyo. Worth several dollars each.
Stock #2035-S ..... $1.00 Postpaid

PORRO PRISM SET FROM ARMY'S 6 POWER BINOCULAR . . . Consists of 2 Porro Prisms to make an erecting system for a Telescope.
Stock #3010-S ..... $2.00 Postpaid

MAGNIFIER SET . . . 5 Magnifying Lenses . . . Powers from 1 to 10. Various diam. for many uses.
Free Booklet on Home-made magnifiers included.
Stock #1026-S ..... $2.00 Postpaid

SPECIALS IN LENS SETS

Set #1-S "Our Advertising Special" — 15 lenses for $1.60 Postpaid, plus 10-page idea booklet. For copying, ULTRA CLOSE-UP SHOTS, macrophotography, experimental optics, magnifying and for making a two power f/16 Telephoto Lens, "Dummy Camera", Kodachrome Viewer, DETACHABLE REFLEX VIEWFINDER for 35 mm. cameras, stereoscopic viewer, ground glass and enlarging focusing aids, TELESCOPES, low power Microscopes and for many other uses.

Set #15-S — "The Experimenter's Dream" — 62 Lenses, Prisms and Optical Items, and New 50-Page Book, "Fun with Chipped Edge Lenses". $15.00 Postpaid. The variety of Lenses and Prisms in this set will enable you to conduct countless experiments, build a great variety of Optical Equipment. A sensational buy.

NEW 50 PAGE IDEA BOOK "FUN WITH CHIPPED EDGE LENSES"

Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above. . . . only $1.00 Postpaid.

RAW OPTICAL GLASS . . . An exceptional opportunity to secure a large variety of Optical Pieces both Crown and Flint glass (seconds) in varying stages of processing. Many prism blanks.
Stock #703-S 8 lbs. (minimum weight) $5.00 Postpaid
Stock #702-S 1½ lbs. ..... $1.00 Postpaid

KELLNER EYE PIECE LENS . . . Focal Length 1¼ inches. Diameter of eye lens 16 mm. Diameter of field lens 25 mm. Eye achromat already cemented.
Stock #6108-S ..... $1.00 Postpaid

PERFECT ACHROMATIC TELESCOPE OBJECTIVE LENS . . . Diam. 1¾ inches, F.L. 20 inches.
Stock #6091-S ..... $5.00 Postpaid

CLEANING BRUSH SET . . . For Lenses, Optical instruments, etc. Perfect quality — 12 inch Flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
Stock #504 (Reg. 6.00 value) . . . Price $1.00

LENS FOR KODACHROME EYE-VIEWER . . . Color corrected cemented lens 41 mm. diam., 66 mm. F.L.
Stock # 6116-S..... $1.00 Postpaid

MISCELLANEOUS ITEMS

Stock No.	Item	Price
3006-S	Porro Abbe Prism	$ .25 each
3016-S	Pentagon Prism	.75 each
2024-S	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm. — for making Filter)	.25
1004-S	2 reducing Lenses	1.20
3001-S	Lens Surface Prism	2.00 each
503-S	No. 1 Sable Hair Lettering Brush	1.00 dozen
3021-S	Amici Roof Prism (3rd Grade)	.25 each
4009-S	Heat Absorbing Glass 4" x 5"..	.35 each
4010-S	Heat Absorbing Glass 2" x 2"..	..10 each
2020-S	40 mm. Neg. Lens, Cross Lines..	.25 each
3020-S	Right Angle Prism 48 mm. wide (3rd grade)	.35 each
523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼"	.25 each
1027-S	Perfect Plano-Convex Lens, Diam. 12.5 mms. F.L. 20 mms.	.30 each
624-S	Neutral Ray Filter size 4¾" x 2½"	.25
3022-S	Round Wedge 65 mm. Diam. ...	5.00 each
3036-S	Roof Prism — 80 degree face 1⅝" wide	4.00 each
22-S	Inclinometer — Aircraft type ..	.25 each
704-S	Lens Cleaning Tissue, one ream (480 sheets) size 7½" x 11"..	1.50
6002-S	Educational Set. 1 blank and 1 finished Perro Prism (3rd grade)	.25 set
1003-S	50 Power Microscope Lens Set ..	.70
1028-S	8 Power Mounted Magnifier	.35 each

(Minimum order — $1.00)

COLOR FILTERS

1 Red and 1 Yellow Filter in following Diam.

20	mm. (seconds)	40c	45.5 mm. (seconds)		90c
32.5	mm. (seconds)	70c	31 mm. (seconds)		70c
37	mm. (seconds)	70c			

(Minimum Order on Above—$1.00)

WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in mms.	F.L. in mms.	Comments	Price
6019-S	15	41	Cemented	60c
6111-S	16	36	Cemented	75c
6094-S	16	75	Cemented	$1.00
6115-S	46	108	Cemented	$1.00

USES:—Use these Lenses for making Projecting Lenses, Low Power Microscope Objectives, corrected Magnifiers, substitute enlarging Lenses, Eye Piece Lenses, Macrophotography gadgets, optical instruments, etc.

TANK PERISCOPE

Complete Set Mounted Components

Rugged, strong, originally constructed for U. S. Tank Corps. Consists of 2 fine Periscope Mirrors mounted in metal and plastic. Only plywood body frame is required to finish this exceptional Periscope. First surface mirror is well protected by glass windows. Set weighs 2¾ lbs. Overall length of mount 6⅛", width 2⅛". Would normally retail at $40 to $50.
Stock #700-S .... $3.00 Complete Set Postpaid
TWO SETS (4 UNITS)..SPECIAL $5.50 Postpaid

ORDER BY SET OR STOCK NO. ✦ SATISFACTION GUARANTEED

EDMUND SALVAGE COMPANY ✦ P.O. AUDUBON, NEW JERSEY

difficulties in getting under way.

4. Steering linkage has been redesigned to provide ease of handling and free rolling, and to make it possible to negotiate sharp turns more safely.

5. Greater rigidity is built into the chassis frame. At front and rear, and all along the frame, reinforcements have been added to aid in the attachment of implements, and to absorb the loads of heavy draw-bar work.

6. Rear shock absorbers are mounted at an angle to provide a level floor. New and more comfortable seats have been installed.

7. The gear shift lever is located on the steering column.

Additional features have been provided in the new Jeep, either as standard equipment or as accessories. Among these are seven-inch headlights which meet all legal requirements, a tail gate which enables the vehicle to function effectively as a pick-up truck, an automatic windshield wiper, a large tool box, and front and rear tops.

Owners of the vehicle will be able to purchase a list of special accessories which widen the range of the Jeep's usefulness, including snow plow and grader attachments, spray painting equipment, and others. A belt-driven governor is available and can be installed wherever constant engine speed is required regardless of load. Controlled from the instrument panel, the governor permits regulated engine speeds from 1000 to 2600 R.P.M. in steps of 200 R.P.M.

By no means new, but increasingly effective for post-war use, is the four-wheel drive, never before available to civilians in a vehicle of the Jeep's size and weight. This feature, which helped build a world-wide reputation for the military Jeep, promises to play an equally important part in hundreds of peace-time assignments. By spreading the Jeep's drive over four wheels, tremendous tractive power is achieved and the vehicle becomes a glutton for tough terrain. It is particularly effective on uneven or loose soil, where vehicles driven from only one axle frequently push their front wheels into the ground and stall. On the Jeep, the front wheels do not push, they pull.



Builds fences in a jiffy. Jeep can carry posts, operate hole-drilling augur, and stretch wire afterwards

JOBS—The list of jobs which the post-war Jeep will do runs into the hundreds. Many of these already have been studied and tested; others will receive attention soon. Some of the farm jobs include: Operating a combine or binder; threshing wheat; baling straw; elevating grain; planting and cultivating; plowing; disking; dragging; hauling grain, hay, and livestock; mowing and raking hay; operating a post-hole augur; sawing wood; filling a silo.

In addition, the Jeep can successfully: Operate an electric light plant; maintain utility lines; serve in mines; act as police patrol; deliver mail; move airplanes on field; skid logs; herd cattle; move yard freight; pump water; stretch fence wire; plow snow; service oil fields.

The Jeep has successfully served as a mobile power unit for a movable air compressor and for effective pavement breaking and street repair.

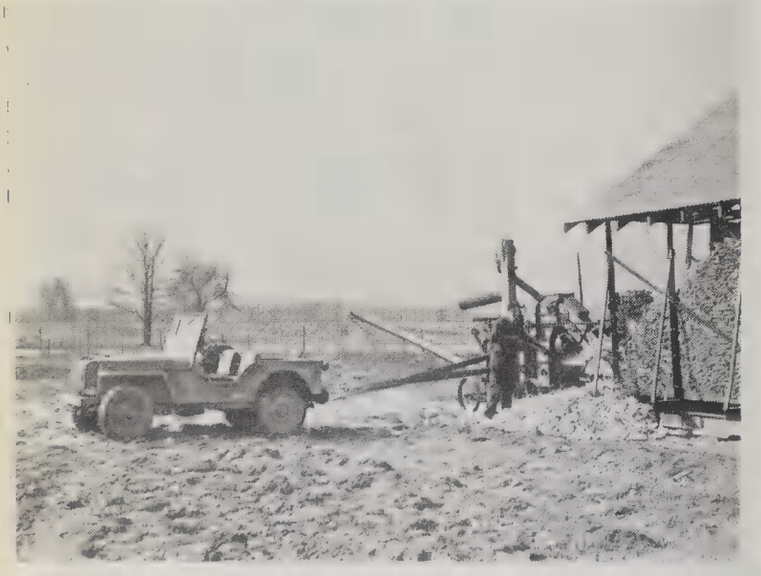
GAS CONSUMPTION—There has been much discussion about the Jeep's gas consumption record. Extensive field tests have proved the post-war vehicle's economy compared with other forms of tractive power. On the highway, it will deliver up to 18 miles per gallon. It is also economical in belt pulley operation. It is well to remember that gasoline consumption is a matter of how efficient the engine is, how heavy the load may be, the quality of gasoline used, whether time saved is more to be valued than gasoline consumed, and whether the vehicle being tested is moving over hard-surfaced roads or through mud, sand, or loamy soil.

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BUSINESS FLIGHTS

In Private Planes
Save Executives' Time

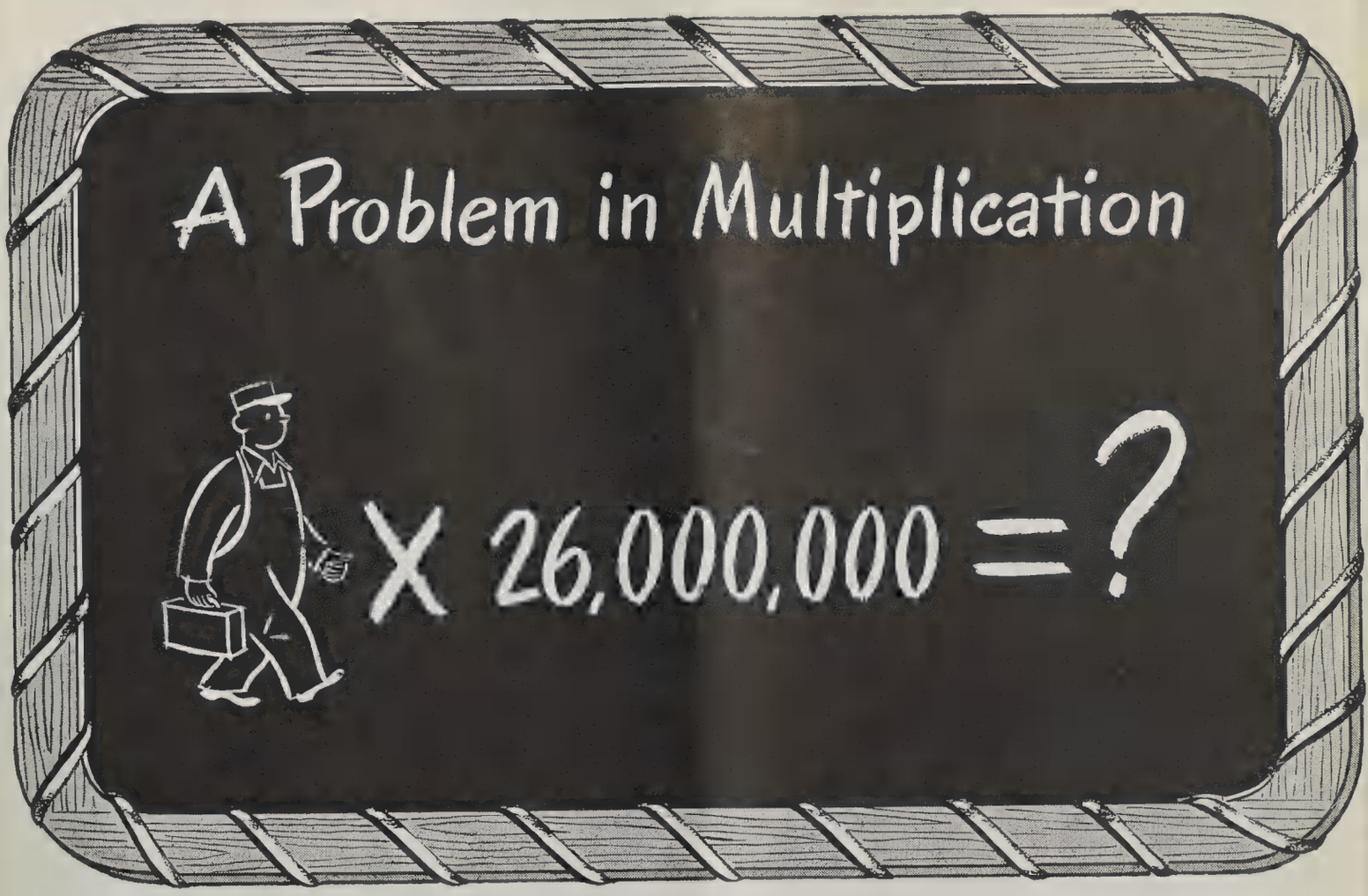
How APPRECIABLE savings in time and money can be achieved through travel in privately operated aircraft has been shown by the Civil Aeronautics Administration in connection with its contract termination program. On that assignment, more than $4500 in fares, subsistence, and salary time was saved by use of a Government-owned airplane. The



Versatile Jeep tows the corn husking machine to crib and is then put to work operating the long power belt



Taking the saw mill to the tree instead of the tree to the saw mill. The saw mounting folds into back of car



Take the case of John Smith, average American:

For over three years now, he's been buying War Bonds through the Payroll Savings Plan. He's been putting away a good chunk of his earnings regularly—week in, week out. Forgetting about it.

He's accumulating money—maybe for the first time in his life. He's building up a reserve. He's taking advantage of higher wages to put himself in a solid financial position.

Now suppose *everybody* in the Payroll Plan—everybody who's earning more than he or she needs to live on—does what John Smith is doing. In other words, suppose you multiply John Smith by 26 million.

What do you get?

Why—you get a whole country that's just like John Smith! A solid, strong, healthy, prosperous America where everybody can work and earn and live in peace and comfort when this war is done.

For a country *can't help* being, as a whole, just what its people are individually!

If enough John Smiths are sound—their country's *got* to be!

The kind of future that America will have—that you and your family will have—is in your hands.

Right now, you have a grip on a *wonderful* future. Don't let loose of it for a second.

Hang onto your War Bonds!

BUY ALL THE BONDS YOU CAN...
KEEP ALL THE BONDS YOU BUY

Scientific American

This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Counc

value of an aircraft to business executives was further demonstrated by the 83 percent time saving. Actual time spent traveling was less than 103 hours by air against more than 609 that would have been required by rail.

The trip was made by a CAA Contract Termination Board of four members, one of whom served as pilot. They made 63 stops in 108 days. Best possible time by rail would have been 146 days, assuming trains would be scheduled exactly as needed. Time saved by the Board was probably greater than would be the case in many business trips, however, because much of its business was conducted at airports. It was also true that the trip was made during favorable flying weather—only twice in 108 days was the plane grounded because of weather.

The cost of operating the plane, including depreciation, was $886.47 less than train fares would have been. The time saving of 152 man days represented $3626.72 in cash, on the basis of $17.86 average daily salary plus $6.00 per diem subsistence allowance.

EIGHT CHANNELS

Now Used on One Radio Transmitter

THE SUCCESSFUL use of an eight-channel system for transmission over a single radiotelegraph transmitter is announced by RCA Communications, Inc. The new system has been placed in operation between New York and London with extension channels to San Francisco.

Specially designed equipment operating on "time division multiplex telegraph" principles, permits handling of 488 words per minute inward and outward simultaneously, corresponding to eight channels each way with an individual channel speed of 61 words per minute. Four or two channels instead of eight can be used if desired. All eight channels may be utilized for two-way communication with one distant station. Alternatively, they may be set up in such a way that four channels with a total capacity of 244 words per minute can be operated in both directions simultaneously between two different stations.

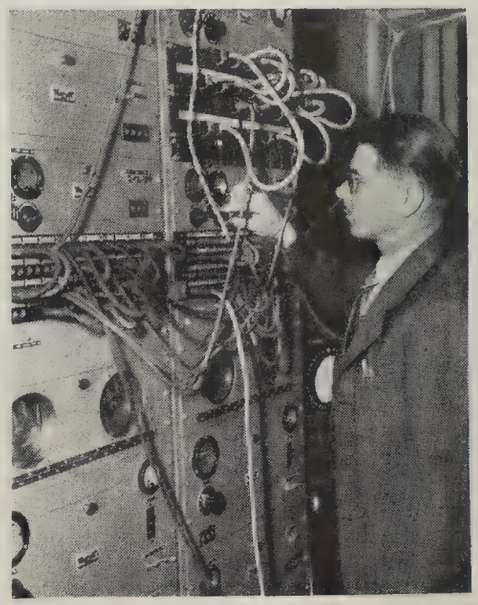


Multiplex distributor for eight-channel system, showing channel switch

The printing mechanism accomplishes the feat of making the circuit virtually error proof, despite its high speed. A warning bell rings when a mutilated character is transmitted and a Maltese cross marks the exact spot of the error, facilitating correction. In other words, no error can get through directly to the message blank. The printer, known as the RCA Seven Unit Printer, is completely automatic. Each incoming letter is comprised of three marking (signal) impulses, plus four spacing (no signal) impulses. The name—seven unit—stems from this fact.

Although the new multiplex equipment is specifically designed to utilize the RCA Seven-Unit Printer System, it is also able to handle other telegraphic signalling codes. In fact, a different signalling code can be used if desired on each of the four pairs of channels forming the eight channel total.

In spite of its speedy performance the appearance of the transmitting and receiving equipment used is but slightly different from the conventional radiotelegraphy apparatus. One of the valuable features of the new system is the use of bells for signalling, each channel using two of them. One rings only when an incorrect group of signal elements reaches the receiving printer; the other, of different pitch, is operated by means of a switch similar to a telephone dial, and with it the receiving operator can pass a number of stock phrases for service instruction to the other end of the circuit, thus saving channel time.



Making an adjustment on one of the control panels of the new multiplex radio sending and receiving system



Punching tape for message transmission over eight-channel radio system

BETTER EYESIGHT

Will be Sought by American Workers

WAR PRODUCTION efficiency studies have disclosed that approximately one out of every three American workers has an uncorrected visual handicap, and as a result of these disclosures wide interest is developing in industrial visual problems, according to M. J. Julian, president of the Better Vision Institute.

"War production has spotlighted the problems of inadequate seeing conditions in many factories, the neglect by workers of their visual shortcomings, and the adverse effects of visual fatigue upon productive efficiency," says Mr. Julian. "The problem of better seeing for economic efficiency is being attacked in four general directions:

"First, professional ophthalmic men are studying visual needs of workers and are assisting in the formulation

of occupational eye care programs. Seeing requirements of various jobs are being analyzed so that workers may tune up their eyes for the most effective vision on their own particular jobs.

"Second, many industries are carrying on extensive educational programs to bring about higher standards of occupational eye care. Experience gained during the war has demonstrated to employers that half-seeing workers are an economic liability to the productive process.

"Third, the public generally is accepting higher visual standards as prerequisite to higher living standards. As a result workers in increasing numbers are taking steps on their own initiative to keep their eyes tuned to high efficiency.

"Fourth, many industrial plants are making surveys of working conditions to improve 'seeability.' Lighting of factories is being improved to provide greater comfort to the eyes of workers. Machines are being painted to facilitate seeing by pleasing contrasts of color. Efforts are being made to coördinate seeing skills of workers with jobs best suited to their particular visual qualifications."

MAGNETOCHEMISTRY

Is Revealing Many Unsuspected Facts

MAGNETIC studies, one tool of the chemist, are discovering new facts about catalysts, the vitally important "marrying parsons" in many chemical reactions, Dr. P. W. Selwood, associate professor of chemistry at Northwestern University, said in a recent address delivered before the American Chemical Society.

"Catalysts bring about or speed up chemical reactions without being affected themselves, but not much is known yet about the fundamental way in which they operate," Dr. Selwood said.

"Magnetic studies are just beginning to reveal certain hitherto unsuspected facts such as the nature of the activation process in catalyst preparations, the effect of diffusion, and the physical and chemical state of the various elements present in commercial and laboratory types of catalysts."

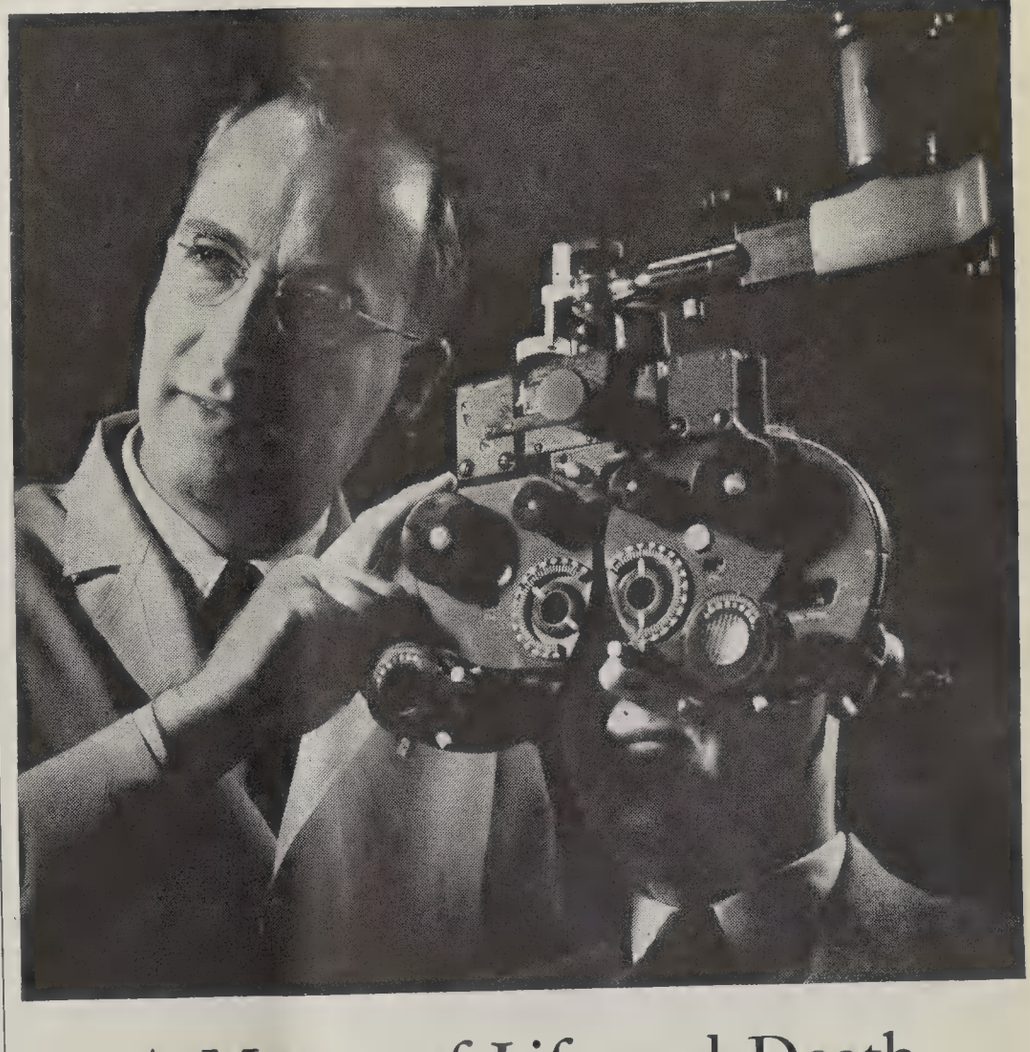
"From the nature and degree of magnetic attraction or repulsion," he explained, "it is possible to draw conclusions as to the structure of chemical compounds, the electrons in the molecules, the presence of impurities, and the mechanism of certain chemical and physical changes.

"The magnetic method is especially powerful in detecting minute traces of impurities, such as iron. As little as one part of iron in 1,000,000,000 parts of copper is easily detected. This method is convenient in testing and controlling the purity of raw materials and products, such as glass sands, activated alumina, rare earth preparations, and many other types of highly useful chemical substances."

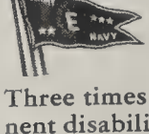
"The magnetic measurements," he continued, "are also useful in studying organic free radicals, and studies of this kind may lead to a better understanding of the way in which plastics are formed.

"Similarly, the chemical structure of hemoglobin and of other complex compounds has been greatly extended by magnetic measurements. Some substances found in the animal body contain minute traces of iron which is, nevertheless, indispensable for life. Magnetic studies have shown how the iron is combined in these substances and, in some cases, have led to improved methods for studying blood chemistry.

"Magnetic measurements are also useful in powder metallurgy. Powder metallurgy is the art of making metal objects, such as gears, bearings, et cetera, by compressing and heating finely powdered metals or mixtures of metals. Recent studies have shown how the magnetic properties change



A Matter of Life and Death



During 1945, nearly a hundred thousand Americans will lose their lives—*victims of home-front accidents.* Three times that many will suffer permanent disability. And the cause for many of these accidents will be faulty vision, or vision unsuited to its tasks.

You might never think of an eyesight examination as a matter of life and death. But the things you do at work, at home, on the farm, or in traffic—the hazards of everyday living—require efficient, alert eyesight. Keen vision is safe vision; reduction of accidents is a matter of national urgency.

The only way you can be sure about your vision is to consult an ophthalmologist or optometrist for a complete visual analysis. If correction is called for, you can depend on the professional and technical skills of the optometrist or optician to provide modern attractive eyewear.

Play safe—*be sure your vision is right.* Bausch & Lomb Optical Co., Rochester 2, New York.

BAUSCH & LOMB

ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry, and Eyesight Correction and Conservation

during this process, and how they may be used to follow the rate at which the powder grains of one metal diffuse into those of another."

GAS-DIESEL

Can Show Great Savings In Sewage Plant

GAS DIESEL engines could save at least $33,000 a year in the operation of Cleveland's Southerly Sewage Treatment plant, a study of that plant's operation has just revealed and this serves as an indication that many additional thousands of dollars could be saved in similar plants throughout the nation by the application of the new engineering principle, according to Ralph L. Boyer, Cooper-Bessemer chief engineer.

The new gas-Diesel engine could save money by providing power facilities for utilizing the maximum sewage gas output instead of the minimum as now set up for units capable of using only gas for fuel, Mr. Boyer says. The new gas-Diesel development could also be used as a means of generating electricity for plant motor units on a self-sustaining basis.

Sewage plants now equipped with ordinary gas engines must necessarily provide for seasonal fluctuations of their sewage gas supply and, therefore, their engine installations operate on the basis of the minimum of gas production. When the gas supply exceeds these minimums, the surplus is frequently burned in the atmosphere.

By using the new gas-Diesel engine, the horsepower could be based on the plant's maximum capacity, with a standby fuel-oil supply available for use during seasonal declines in the gas supply. With the new gas-Diesel principle, it is possible to run on any percentage of gas available by adding fuel oil to supply any additional requirement. Thus, an engine now can run on 80 percent gas and 20 percent oil, or any other similar combination of fuels.

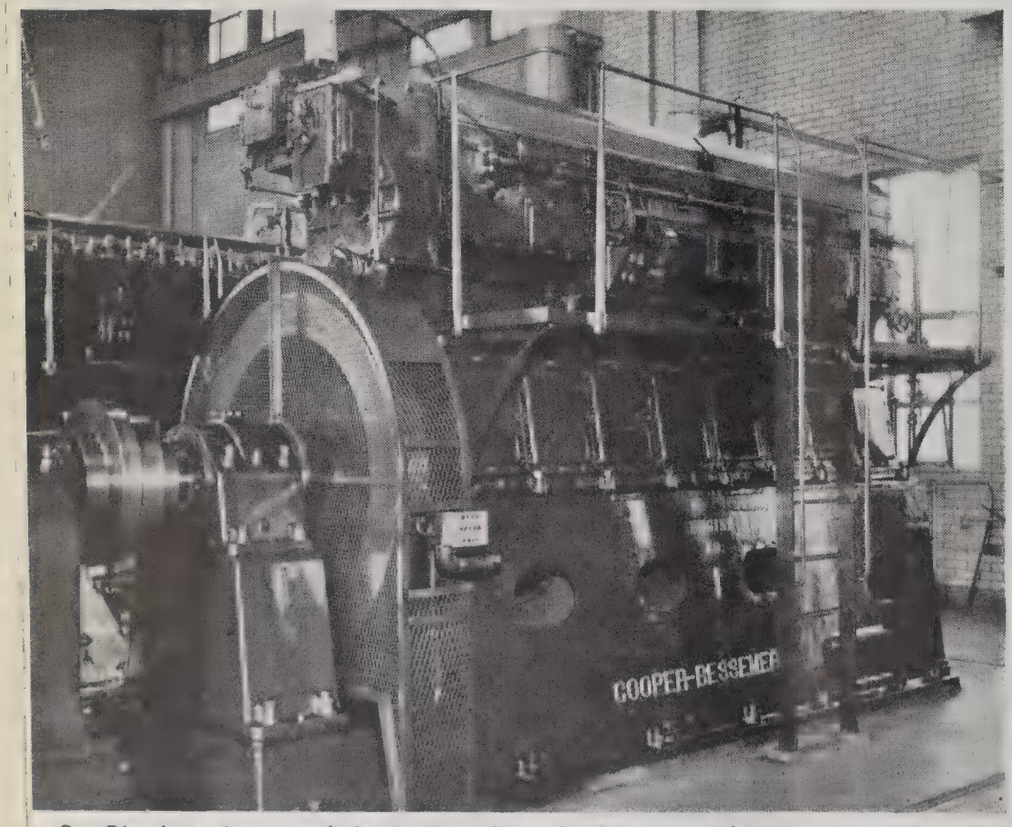
RUBBER TRACKS

Seen as Having Agricultural Advantages

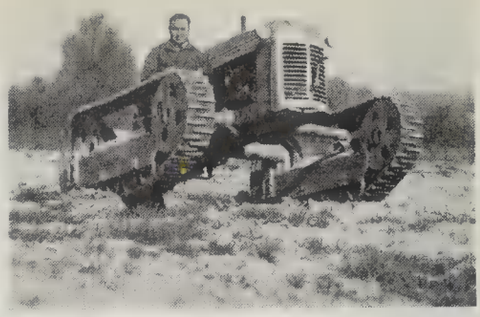
A POST-WAR "back to the farm movement" for rubber tracks of the type used on tanks, Weasels, half-tracks, and other bouncing land battle-wagons is predicted by The B. F. Goodrich Company.

Originally designed for industrial and agricultural use—the first continuous-band rubber track was applied to a farm tractor in 1931—rubber tracks have "made rapid strides," figuratively and literally, during the war. The application of these new high-performance tracks to civilian vehicles is said to be a logical next step after the conflict ends.

The "sprinter" self-track-laying vehicles of this war are a far cry from the lumbering, thundering, vibrating tank treads of World War I. They move at high speed without excessive vibration and travel over macadam or concrete roads without undue punishment either to themselves or the paving and have several advantages over wheels for vehicles in "off-highway" use. They



Gas-Diesel engines, used in sewage disposal plants, can be run on maximum sewage gas supply, using fuel oil for standby operation when gas supply is low



A post-war track-laying farm tractor

have a drawbar pull nearly twice as great as that of wheels and provide better and more uniform traction. They make a broader area of ground contact than do wheels, and thus have a greatly reduced shearing force per unit of ground contact. Over "washboard surfaces"—for example, at a right angle to old corn rows—they provide a smoother ride, causing less fatigue to the operator. Their substantially lighter pressure per unit of ground contact reduces soil packing.

TENT CLOTH

Production-Treated With Synthetic Resins

CONTINUOUS production of water-, fire-, and mildew-proof duck for Army tent cloth is made possible through the use of synthetic resins which were developed to meet war-created shortages of imported materials. These resins have made possible a duck that actually wears longer, demonstrates increased strength over a period of years, and resists weathering and fungi better than pre-war tent materials.

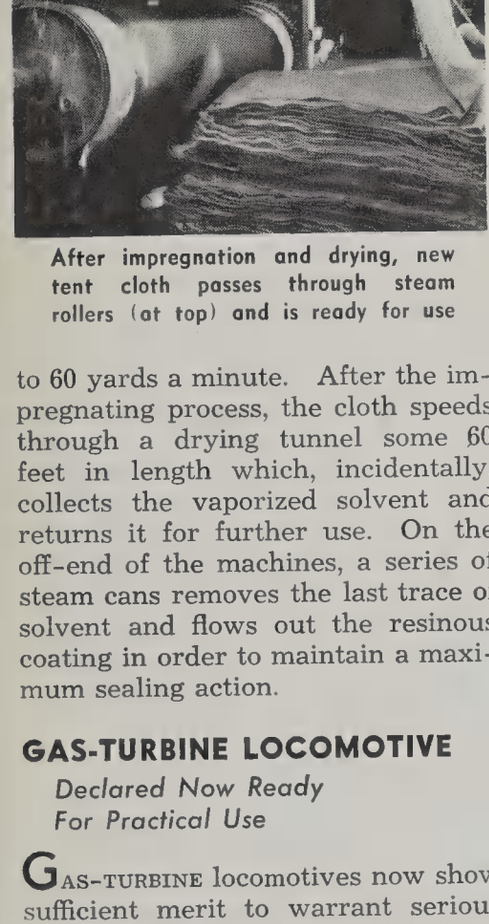
In the early stages of the war, mildew destroyed one fifth of all goods shipped to the South Pacific. The wide range of weather and service conditions existing in the various theaters of war necessitated a material that would remain flexible at sub-zero temperatures, be completely water- and weather-proof, and exhibit proper coloration and lasting color retention. In addition, a replacement had to be found for one of the basic materials normally used to treat tent cloth.

Already familiar with synthetic resins from earlier experience in making book cloth and artificial leather, the L. E. Carpenter Company, with the co-operation of the Resinous Products and Chemical Company, devised a tent cloth coating compound which met the exacting specifications of the Military Planning Division.

The coating compound serves two principal functions. First, by sealing the relatively open weave of the tent cloth it renders it water-proof,

and, second, by acting as a binder and carrier for the flame-proofing and fungus-resisting agents, it protects the duck against fire and deterioration.

The manufacture of tent cloth coating consists in mixing the dry ingredients in a paddle mixer, followed by the addition of various liquid components and the plasticizer. The mix, which at this point has a thick, viscous consistency, is then ground in a large roller mill to insure complete pigment dispersion and a homogeneous mix. From the roller mill, the mixture is passed to the blend tanks where solvent is added and finally pumped to the coating troughs. The canvas cloth is passed through these coating tanks and a series of squeeze rollers at from 45



After impregnation and drying, new tent cloth passes through steam rollers (at top) and is ready for use

to 60 yards a minute. After the impregnating process, the cloth speeds through a drying tunnel some 60 feet in length which, incidentally, collects the vaporized solvent and returns it for further use. On the off-end of the machines, a series of steam cans removes the last trace of solvent and flows out the resinous coating in order to maintain a maximum sealing action.

GAS-TURBINE LOCOMOTIVE

Declared Now Ready For Practical Use

GAS-TURBINE locomotives now show sufficient merit to warrant serious consideration by forward-looking railroad engineers, Paul R. Sidler, resident engineer of Brown, Boveri and Company, Ltd., declared recently in an address before the American Society of Mechanical Engineers. He described operating tests for a period of a year on the Swiss Federal Railways, which constitute the basis of development of the locomotive type that is now offered to American railroads.

"This year of regular service confirmed the results of the earlier trial runs in regard to guaranteed performance," he declared. "All requirements have been fully met; no major disturbances of any kind have occurred. Minor adjustments could always be completed during scheduled waiting periods. Therefore, the availability record is excellent. The operating crews appreciate the simplicity of operation and the flexibility of the power plant."

This type of railroad power, the speaker explained, is designed primarily for long, high-speed runs with few stops, making possible comparison with the large Diesel-electric locomotives used by many carriers. The gas-turbine locomotive developed for American roads consists of a basic unit of 2500 horsepower which can be used singly or may be coupled in units of 5000 to 7500 horsepower.

Coupled to form a 7500 horsepower giant capable of speeds up to 75 miles an hour, the gas-turbine locomotive and tender are 198 feet long and weigh slightly over 1,000,000 pounds. Fuel consumption at full load is 800 gallons of bunker C fuel oil an hour. Starting is achieved by a Diesel-generator group, the entire process taking only about five minutes.



Ingenious New Technical Methods

Presented for Your Peacetime Use

Coming to Users of Gas-Powered Equipment

80% SAVINGS IN CLEANING TIME

With Steam Rig Now the Army's Standby

An economical solution to the problem of cleaning and degreasing trucks, passenger cars, tractors, locomotives, excavators, and the like will be available to garages, service stations, all users of oil-burning equipment, as soon as war demands permit. It is a more efficient steam cleaner now in use by the thousands in the Armed Forces.

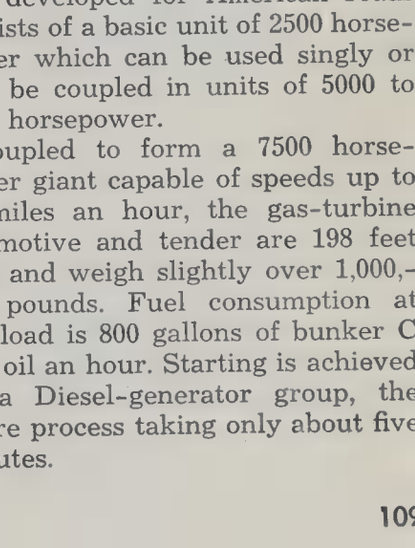
Neat "housekeeping" has too often been neglected by industry due to the costliness of hand labor. But the best housekeepers in the World, the U. S. Army, Navy and Marine Corps, dare not neglect frequent and thorough cleaning of all equipment to safeguard against fire and malfunctioning, and to permit fast, certain inspection. This cleaner, developed to meet their high standards, removes grease, dirt and grit 5 times as fast as any other method. It cleans by a balanced combination of heat, detergent, water and friction. It is typically "army" in simplicity of design and operation; in 30 minutes, the entire machine can be dismantled and completely cleaned.

Wartime uses of Wrigley's Spearmint Gum also point the way that industry may benefit when this quality product again becomes available. It will *again* be a "help on the job" in many ways. Right now *no* Wrigley's Spearmint is being made, as present conditions do not permit the manufacture of Wrigley's Spearmint in quantity and quality sufficient for all. But remember the Wrigley's Spearmint wrapper—it is a certificate of highest quality and flavor—and will always remain just that.

You can get complete information from Clayton Manufacturing Company, Alhambra, Calif.



The Kerrick Kleaner



Remember this wrapper

Z-74

New Products and Processes

SPLINED NUT

Useful for Attaching Accessories

A SPLINED type Rivnut suitable for use in wood, plastics, leather, hard rubber, or other material where it is necessary to anchor a nut firmly for attaching accessories is announced by The B. F. Goodrich Company. This type is an addition to the regular line of Rivnuts now being adapted for use in many fields, including aircraft, automotive, refrigeration, and electrical equipment.

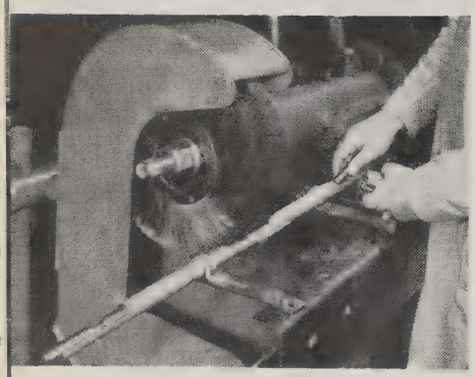
In the new type, splines beneath the countersunk head supply resistance to torque, while the bulge or "upset" which forms below the end of the splines furnishes the tension resistance. The splined Rivnut is thus locked into place two ways. Internal threads left intact within the shank take an attachment screw for installation of accessories.

FAST FINISHING

Of Metal Parts by Use of Special Fixtures

Two shop-made holding fixtures that provide power brushing with a new and effective means for fast output of properly cleaned and deburred metal parts, were recently reported to The Osborn Manufacturing Company.

One is a hand-made pair of forceps for holding tiny splines against a brushing wheel for removal of burrs and other surface irregularities. The use of



Two simple fixtures for power brushing. Above: A pipe holds threaded studs. Right: Forceps grip small parts

different sized holding heads makes this idea applicable to various sizes and shapes of parts to be brushed.

The other shop-born idea is for stepping up production in power-brushing threaded studs. This holding fixture employs a pipe placed at a level which enables it to employ gravity as an aid in the feeding. Opposing the gravity is a small side brush which extends through the pipe opposite the brushing wheel. When the threaded stud reaches this opening and comes in contact with the power brush, it also engages the small side brush. Since the power brush rotates the threaded part, it follows the course of the threads from one end to the other and controls the time the part is in contact with the brushing surface.

If the part being brushed is made of soft material, the pipe could be of plastics or other composition. This would avoid damage to the external threads as they pass through.

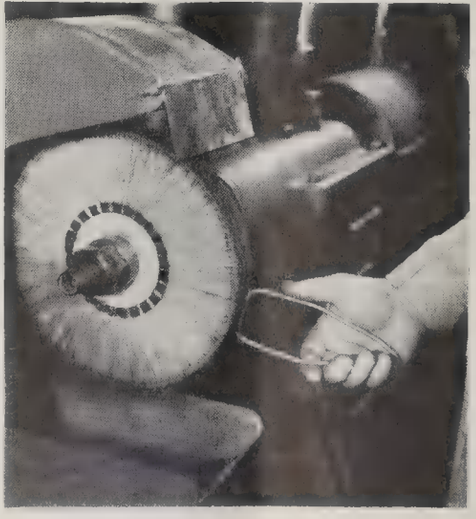
RECTIFIERS

Made of Selenium, Have Many Advantages

PROGRESS in the development of selenium power rectifiers for converting alternating to direct current on large aircraft is reported by A. L. Embry, design engineer of tungar and metallic rectifiers for General Electric.

Many of the large planes of the future will have auxiliary power generated as A.C. but considerable amounts of D.C. power will still be required, Embry says. The selenium rectifier will, therefore, have a wide field of application, he states. It has several advantages as a means of conversion: It does not have the high voltage drop of an electronic tube nor the moving parts and brushes of a rotating machine; it is simple, reliable, and easy to maintain; for three-phase power input it can be designed for 85 percent efficiency; weight of a complete unit, including transformer and voltage regulating equipment, compares favorably with that of a motor-generator set of the same rating.

According to Embry, selenium rectifiers can be used with transformers to obtain any desired output voltage. Input may be single phase or polyphase. The widest present application is for 28.5-volt D.C. units with three-phase

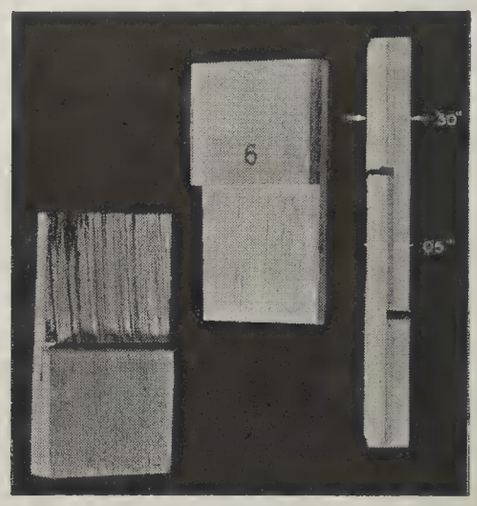


input. He says that for some applications where the D.C. load is substantially constant it may be practical to use selenium rectifiers without voltage regulation. Such rectifiers may be designed to operate directly from the A.C. line or with a suitable transformer to provide any desired direct voltage.

RESIN ADHESIVE

Made Craze-Resistant For Wood Assemblies

A CRAZE-RESISTANT urea-formaldehyde resin adhesive that offers improved bonding for intricate wooden parts where the application of high pressure to secure a uniformly thin, durable glue



A plywood shear specimen, with Urac glue line .05 inch, before and after. Note high percentage of wood failure

line has heretofore been extremely difficult, has improved features for low-pressure wood assembly work in the aircraft, furniture, automobile, marine, woodworking (including lumber lamination for wooden structures and buildings), sporting goods, and musical instrument industries. It greatly reduces the problem of crazing or fine cracking of the glue which causes deterioration of the glue lines.

Other advantages of the new adhesive, named Urac 183, over present craze-resistant adhesives, are stated by the American Cynamid Company to be: (1) greater storage stability; (2) elimination of amylaceous fillers; (3) control of glue-line pH to values acceptable under U. S. and R. C. A. F. specifications; (4) lower cost; and (5) provision of Hardener system for summer temperature use.

With Urac 183 in low-pressure bonding, glue line thickness up to .020 inches may be tolerated. This is of particular value in low-pressure assembly gluing where complex shapes prohibit perfect joining and high pressures are not applicable to insure uniformly thin glue lines.

SENSITIZED PLYWOOD

Makes Possible Highly Accurate Templates

PHOTOGRAPHICALLY sensitized plywood has been put to work in the design and tooling rooms of a leading aircraft manufacturer. Both interior and exte-

rior (water-proof) types of plywoods from one eighth of an inch to two inches in thickness are used for wiring boards, templates, form blocks, instruction boards, display photographs, and a multitude of other uses.

Douglas fir and maple plywoods are used most commonly and these are sensitized with a liquid-type photographic emulsion directly on either the unpainted or painted surfaces of the wood. A preliminary coat of white paint improves the contrast and makes reading easier. Plywood templates are particularly advantageous in the production of new experimental models as they give accurate information and quickly are converted into assembly jigs by attaching maple blocks and fixtures which are used to locate and hold the parts. The process is described by an engineer of the Boeing Aircraft Company as follows:

Liquid photo emulsion is applied to the surface of the plywood by using a paint spray gun, the interior of which has been chrome or silver-plated to prevent contamination from the brass parts in the gun. Actual spraying is carried on in a standard spray booth which is located in a ruby-lighted room.

Plywood templates are reproduced with a huge photo template camera by projecting glass plate negatives, previously made by photographing master layout drawings. The master layouts are hand-drawn on large lacquered steel sheets. When a draftsman has completed a layout it is photographed by the precision template camera at one-fifth the scale of the original drawing. A glass negative is used so that there will be no shrinkage or distortion.

After exposure, the glass negative is processed, dried, and placed back in the camera. A projection light is moved into place and the image is projected on a sensitized sheet of plywood to the exact scale of the original drawing.

SUPERCHARGING

Now Used On Gas Engines

SUPERCHARGING of gas engines and instantaneous conversion from the use of either oil or gas fuel is a new development announced by The Cooper-Bessemer Corporation. The new development is said to accomplish the following improvements:

1. In the oil field, it will make possible use of supercharged engine of the gas-Diesel principle in the drilling of deeper wells which predominate today. For example, at the beginning of a drilling project the operator could use oil as fuel in the absence of a ready supply of gas. The engine could be converted instantly to gas while under full load.

2. In oil and gas pipelines, in addition to affording greater economy in operation, either gas or oil could be used for engine operation, depending upon availability of the supply and relative costs.

3. In oil field central pumping plants, it should be an important factor in increasing the economy and movability of these plants which are moved from one point to another as they complete their operations.

4. Stationary power plants will profit from the new development through concentrating the greater horsepower of the supercharged engines into less space than was necessary heretofore. This materially reduces building and foundation costs.

INTERFERENCE

Reduced for Airplane and Automobile Radio Receivers

ENGINE ignition static, the foremost interference in aircraft and automobile radios, can now be completely eliminated without reducing engine operating efficiency, it is claimed, by means of a new-type ignition system invented by Victor Welge, an electronics expert for Consolidated Vultee Aircraft Corporation.

Previously, there was no satisfactory method of cutting out engine noises in aircraft radio sets and, consequently, aircraft radio communications were often difficult to understand. Suppressors made automobile radios function with considerable clarity, but these units could not be used in airplanes because they reduced ignition efficiency.

Welge's ignition system is simply a new method of wiring and shielding. Its purpose is to confine radio-frequency disturbances to an engine by providing an isolated return path for



Selecting milk bottles for shipment. Overweight bottles are rejected because of shipping weights . . . under-weight containers to avoid customer dissatisfaction—Lamb Glass Co., Ohio

An Ages Old Industry Goes Modern . . .

GLASS is as old as history itself. Medieval artisans molded it with bare hands and skill alone. Colors, although not uniform, were rich and beautiful. With the coming of the industrial revolution, as in all things, silicate sand, soda ash and cullet were compounded by weight . . . color blending became uniform with the use of precision scales . . . engineers check-weighed glassware at the Lehr, "hot end" . . . glass container selection (illustrated above) became standard proceedure at the "cold end". No industry today depends so completely upon scales in production . . . no industry through the ages has been so entirely changed in the making of a product than has the glass industry. It has truly gone modern. EXACT WEIGHT Scales have played a vital part in every aspect of this revolution.

INDUSTRIAL PRECISION

Exact Weight Scales

THE EXACT WEIGHT SCALE COMPANY

85 West Fifth Ave., Columbus 8, Ohio

Dept. Ad. 783 Yonge St., Toronto, Canada

the sparking current which ignites gasoline in the engine cylinders. Engineers report that, besides eliminating the engine noises in aircraft radios, Welge's ignition system operates with unprecedented sparking efficiency.

LIGHTNING ARRESTER

Has Strong and Transparent Plastics Cover

RARE GAS lightning arresters for fire alarm and telephone and telegraph circuits are now protected by housings of transparent Tenite plastics. Molded in two halves, the housing fits around the cartridge and fastens by means of interlocking lugs produced in the mold. The two metal ends of the cartridge are slipped on over the Tenite housing.

In the presence of lightning or high-voltage circuits, the glow which indicates proper functioning of the arrester is clearly visible through the plastics. The electrodes are sealed inside and kept free from atmospheric conditions, dirt, insects, and other maintenance problems.



Transparent lightning arresters

BIGGEST TIRES

Now Constructed from Synthetic Rubber

CONSTRUCTION from synthetic rubber of the world's largest tires, each with 140 times as much rubber as the average passenger car tire, was accomplished recently. Weighing more than most automobiles, the giant tires are used on earth-moving equipment needed in the construction of military airports and highways. Because the tires must support the equivalent of up to 24 large truckloads of earth and often must operate in rocky areas, they must be particularly resistant to cutting, impacts, heat, and separation of plies. These are the four worst enemies of synthetic rubber tires.

The Firestone Company solved the impact problem by a special cord construction; the cutting problem by mixing new strengthening materials into the synthetic rubber; the heat problem by using rayon cord and an improved synthetic rubber compound; and the adhesion problem by using a hair-thin layer of natural rubber between the plies or layers of the tires.

The great size of these tires is necessary so that they will not sink into mud when weighted down with their heavy loads. The largest earth-moving tire is 9½ feet high.

This giant, cured in the world's largest tire curing equipment, is more than three feet wide. The area of it in contact with the ground at any one time is 1303 square inches—as large as a dining room table. One of these tires contains three miles of piano wire, and its tread is more than five inches thick. The tire has 34 plies, in contrast to the four plies used in most automobile tires, and can carry a load of more than 50,000 pounds.

LIQUID INSULATION

Guards Electric Circuits Against Corrosion

CREATED to provide lasting protection against moisture, weather, battery acids, and corrosion, a new liquid insulation can be easily applied with a brush or spray to any piece of electrical equipment. Known as PiB, the insulation, when applied to a wet or drowned-out ignition system, will enable the motor to start instantly, it is said.

When applied to the cable, posts, and top surface of a battery, PiB will stop the formation of corrosion and eliminate short circuits across the top of the battery. It is also effective in waterproofing motors and transformers, generators, or other electric circuits subject to corrosion or condensation.

VISIBILITY

Of Mobile Equipment Increased with Stripes

CAMOUFLAGE to conceal fighters and their equipment in battle zones has been raised to a science, but in factories the opposite of camouflage—visibility—is the much-desired goal and safety engineers are studying ways of protecting men and machines by revealing their presence and movements.

The illustrations show a simple but effective method which safety engineers use for increasing visibility of mobile equipment by applying contrasting color combinations of stripes or bars. In one, an Elwell-Parker fork truck is shown tiering bundles and boxes of carton paper in a Michigan plant; in the other, an Elwell-Parker crane is lifting a heavy load of steel bars in an Ohio aircraft factory. Although a standard color for such equipment is a bright yellow, engineers in these plants have applied the stripes and bars to their fleets of these trucks as an additional safety measure. Luminous paint has been suggested and applied in some instances to trucks used in dim light and hazy atmospheres.



Stripes increase visibility



Safety-striped fork truck

GLASS HANGARS

Shelter Warplanes At Advanced Bases

GLASS cloth, woven of glass fiber yarns and coated with synthetic rubber or resin, has been selected by the United States Army Corps of Engineers for curtains, side walls, and ends in newly developed airplane hangars installed at advance Army Air Forces bases. Structural steel frame work and coated glass cloth are shipped to advance bases where the hangars are assembled for the A.A.F. Use of coated glass fabric for sections of hangars saves a great amount of shipping weight and speeds assembly of the hangars.

Glass cloth, made by the Owens-Corning Fiberglas Corporation, was selected because of its resistance to the effects of mold and fungus, high strength in proportion to its light weight, and ease of handling to fit around plane fuselages. Canvas duck, previously used, was subject to rot from tropical dampness and would not withstand fungus attack. In Arctic regions, canvas would become semi-rigid due to the extreme cold. Glass cloth has good weathering properties and is not affected by tropical heat or Arctic cold. Coatings used on the glass cloth include neoprene and vinyl compounds.

PAINT ON ALUMINUM

Made More Lasting by New Preparatory Method

ALUMINUM and its alloys can now be quickly and economically prepared for painting and lacquering with excellent adhesion and corrosion resistance qualities. The application of this surface preparation can be done either in the shop as a hot immersion process, or, when in the field, by cold-spray, brush, or immersion. The hot-immersion method consists of dipping the work for from three to 30 minutes in

a hot chemical solution, then rinsing and drying, after which it is ready for painting or lacquering.

The cold-spray, brush, or immersion method consists of applying a chemical solution (at room temperature), allowing from 15 seconds to one minute for setting, then rinsing the surfaces free of the applied solution. The work is then dried and is ready for painting or lacquering.

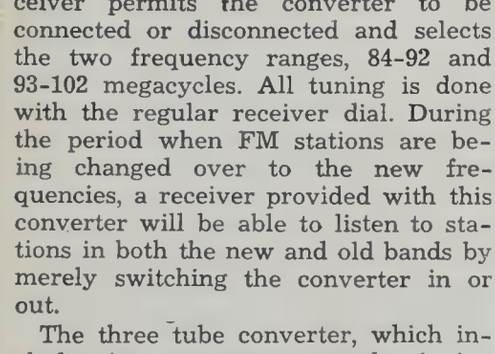
Both methods are reported to be excellent for paint and lacquer adhesion, and in many cases may replace the sand-blasting or anodizing of aluminum surfaces.

FM CONVERTERS

Will Enable Older FM Sets To Tune In On New Bands

TWO CONVERTERS developed by the Hallicrafters Company will permit the reception of FM stations in the proposed new band between 84 and 102 megacycles on pre-war FM receivers built for the old band of 42 to 50 megacycles. These converters were designed and built at the request of the Federal Communications Commission after a Hallicrafters' representative had testified before the Commission that such devices could be used to prevent obsolescence of pre-war sets in the event of a change of FM frequencies.

The single tube converter is designed for use in primary service areas where signal strength is high and the principal considerations are appearance and convenience. It is small enough to go



One-tube FM converter installed in a typical pre-war console radio set

inside the cabinet of practically any FM receiver and will not interfere in any way with normal operation. A switch on the front panel of the receiver permits the converter to be connected or disconnected and selects the two frequency ranges, 84-92 and 93-102 megacycles. All tuning is done with the regular receiver dial. During the period when FM stations are being changed over to the new frequencies, a receiver provided with this converter will be able to listen to stations in both the new and old bands by merely switching the converter in or out.

The three tube converter, which includes its own power supply, is intended for use where signal strength is low and high performance is the prime necessity. This converter is equivalent to the first two tubes of a normal broadcast receiver designed for these frequencies, and will give comparable performance. It is provided with its own tuning dial. When connected to a pre-war FM receiver, the receiver must be tuned to 42 megacycles and the stations in the new band tuned in on the converter.



Precision Finishing of Perfect Circle Piston Rings on South Bend Precision Lathes.

KEEPING MOTOR TRANSPORTATION ON THE HIGHWAYS

America's motor transportation system is delivering the goods despite doubled and tripled wartime demands. Efficient maintenance and a steady flow of vital replacement parts have helped to make this enviable record possible. South Bend Precision Lathes are chalking up enviable records for themselves, too, by turning out repairs and replacement parts in greater numbers than ever before for the shops and men who are keeping 'em rolling longer and further than heretofore seemed possible.



In Service Shops, South Bend Lathes repair, rebuild, remake needed parts.

Write today for the beautiful, complete new Catalog 100-D showing the complete line of South Bend Lathes.

SOUTH BEND LATHE WORKS

LATHE BUILDERS FOR 38 YEARS

458 E. MADISON ST. • SOUTH BEND 22, INDIANA

PHOTOMETER

Analyzes Metals by "Reading" Spectrograms

AN ELECTRIC device that analyzes the composition of metals by "reading" a photographic plate of the metals' spectra, thus indicating the strength or resilience of alloys, is reported by General Electric. Such analysis is of great value to engineers for telling them the maximum endurance of metals used in various kinds of equipment, and the process is considered an important step in the manufacture of a great deal of war material.

Analysis of metals is made by the new device—called the transmission photometer—in combination with a spectrograph. In the process the spectrograph takes a picture of the spectrum of the metal, the resulting image showing the wavelengths of the components arranged as a series of lines. Measuring the densities of these lines to determine the concentration of materials in the metal is where the transmission photometer makes its contribution.

One of the newest and most important application of the transmission photometer is in analyzing the cemented tungsten carbide core of a recently developed armor-piercing projectile. Function of the photometer in this process is to make certain the cemented tungsten carbide, considered the hardest metal made by man, contains the proper proportion of components.

Since the areas involved in reading a spectrograph are extremely small and the variations in density very minute, even the most careful and experienced operators are unable to read the plate density directly, as the transmission photometer does. The photom-

eter reads the spectrographic plate by measuring the intensity of the light transmitted through the plate. In this way it determines the concentration of materials in an alloy with great accuracy and much more quickly than was previously possible.

CONCRETE DRILLING

Speeded by Use of Cemented Carbides

THE THOUSANDS of conduit holes required in concrete ships such as "floating ice-boxes" are now being drilled ten times faster than was previously possible. This is made possible by a new type of masonry drill tipped with Carboloy cemented carbide. Each concrete ship requires some 4000 holes from 1 inch to 2½ inches deep for electrical installations alone. Total number of holes drilled per ship is much higher. Ordinary star drills were employed at the start of the contract, but, in an effort to speed drilling and save maintenance time, Carboloy drills proved so successful that they were adopted as standard.

Secret of the new masonry drill's ability to cut holes through concrete faster than any other available tool lies in the blade inserted in the drill's tip. This blade is made of Carboloy cemented carbide, which is so hard (approaching the diamond in hardness) that it easily cuts through concrete, making possible the drilling of holes and doing away with the prolonged hammering customary with regulation star drills.

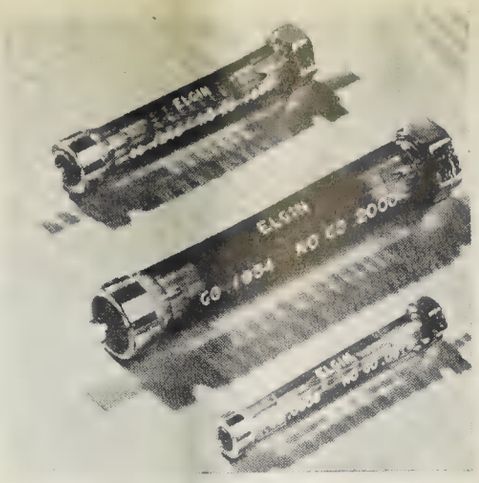


Inserted tip drills concrete fast

PLUG GAGES

Are Fitted with Plastics Handles

HANDLES of sapphire plug gages are now made from hexagonal Tenite rod stock produced by continuous extrusion. Exceptionally light in weight, Tenite makes for a sensitive touch and fine gaging. The plastics is low in thermal conductivity and does not readily transmit heat from the operator's hand to distort the accuracy of the gage. Since both the Tenite and sapphire parts are non-magnetic, the gage may be used without interference near magnetic chucks and steel gaging members.



Tenite, a cellulose acetate butyrate plastics, forms plug gage handles

Sapphire plug gage handles are manufactured by cutting the hexagonal Tenite rod to the proper length, drilling, threading, and slotting the ends to receive the sapphire gaging members. It is possible, because of the resilience and toughness of Tenite, to secure the sapphire parts to the handle by means of a split threaded bushing with locking nut. Lettering and gage specifications are engraved on the handle.

SUNLAMP

Tans Quickly, Fits Ordinary Socket

A SUNLAMP manufactured by Westinghouse can be screwed into any regular light socket operating on standard alternating current.

Engineers claim that only five minutes' exposure is required to mildly redden the untanned skin of a person of average complexion who basks 24 inches from the lamp. To get an equivalent coloring one would have to sit under a July sun for 15 minutes.

Resembling the reflector floodlamp used for show window lighting, the streamline sunlamp emits both invisible ultra-violet radiations of the type known as erythemal energy and infra-red rays, likewise invisible, which provide cozy warmth. A special glass bulb is employed to transmit the ultra-violet and infra-red rays as well as a flood of visible light rays. The ultra-violet is generated by an electrical discharge through mercury vapor. The infra-red is supplied by a tungsten filament inside the bulb—operating at incandescence—which doubles as a "ballast," eliminating the need for the transformer.

Borrowing a principle from the sealed beam automobile headlamp, the rear half of the bulb interior is coated with vaporized aluminum to provide a reflecting surface which insures a high ultra-violet output for the 275-watt lamp's average life of 400 sunbaths.

NEW PEN

Has Ball-Bearing Point, Uses Viscous Ink

USING a miniature ball bearing as its writing contact and viscous ink, a new writing instrument which rolls the ink onto the surface dry, instead of inscribing it wet with a pen point, has just been announced.

The new pen operates on the principle of capillary attraction. It writes with greater ease than the smoothest lead pencil; writes on cloth or paper submerged in water or in an airplane at the ceiling of stratospheric air travel without leaking; writes on glossy paper, soft paper, blotting paper, or cloth without spreading. The ink, being rolled onto the paper or other material, dries as soon as it meets the surface.

Its miniature ball bearing writing contact will write in hair-line or in bold and heavy strokes. It is claimed that the pen cannot leak or drip and that ink cannot be shaken out of it.

The ink cartridge of the pen can be made large enough to contain at least a year's supply—enough for 257 continuous writing hours—and can be replaced with another cartridge in 20 seconds without staining the fingers.

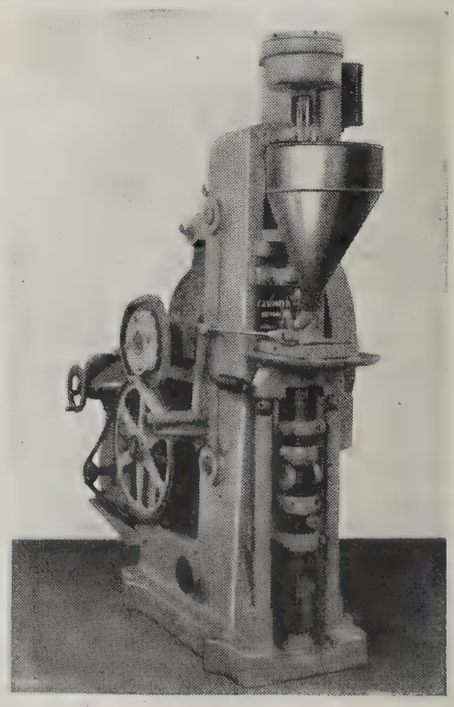
POWDER-METALS PRESS

Quickly Forms Wide Range Of Small Parts

FOR high-speed production, up to 45 strokes per minute in automatic operation on the usual run of work, and to operate also as a start-stop press in making parts with inserts, a new powder-metals press is of 12 tons capacity and of design similar to a model which has been in wide use for many years.

This press is recommended for making small machine parts such as gears, internally or externally splined bushings and ordnance components, carbide tool bits and drawing dies, carbon brushes, brushes with pig-tails and iron cores with threaded shafts molded in place, and many other similar parts.

As a start-stop press the operator simply places the insert in position and pushes a button; the press measures the charge in the usual manner, compresses the material around the insert, and ejects the finished piece, leaving the punch in the "up" position for the next cycle.



High speed powder-metals press

The machine is cam operated, with independent cam control of both upper and lower punch movements. The die table is braced to take the full rated tonnage of the machine, and pressures applied through the punches may be simultaneous or non-simultaneous. An independent secondary lower punch applies pressure up to 2½ tons and may be used as a fixed core rod. The upper punch will stay out of the way during nearly a third of the cycle, to facilitate feeding, and is timed to first descend rapidly and then slowly compress the material with controlled motion. A built-in hydraulic equalizer assures uniform pressure and more uniform density of each piece.

This press, which has a maximum die fill of four inches, is made by F. J. Stokes Machine Company.

HAND TRUCK

Upends Heavy Barrels With Ease and Safety

A BARREL upending truck manufactured by the Colson Corporation makes the handling of heavy barrels safe and



One step in upending a barrel

relatively effortless. In operation, the truck places two hinged lifting arms under the barrel so that when the operator places his foot on a step and pulls back on the handle, the hinged arms contact the barrel side in three successive steps while a fulcrum point slips under the load. The barrel is thus lifted in easy stages until it is upright. A slight forward push then sets the barrel safely on end.

ELECTRIC METERS

Sealed to Withstand Temperature Extremes

BY BUILDING the mechanism of electrical indicating instruments into a protective cup-like frame, and then sealing the glass cover to the metal rim, positive hermetic sealing has been effected with a minimum number of seals. There are no rubber gaskets or cement seals. Tests have proved the effectiveness of the new type of sealing under severe tropical and freezing conditions. The instruments, made by the Marion Electrical Instrument Company, can be immersed in boiling brine solution for weeks, or frozen to minus 40°, Fahrenheit, without deterioration of the seals. This sealing process was developed and perfected in co-operation with the engineers of the Corning Glass Company.

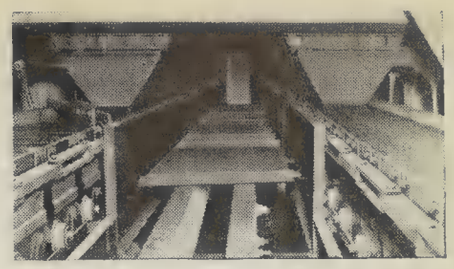
The glass covers employed are of double thickness tempered glass, processed for solder sealing, and are highly resistant to shock. Completely dehydrated, the instruments are filled with dry air at sea-level pressure. A newly designed crowned crystal permits greater scale length, reduces shadows, and makes for better visibility. Magnetic shielding makes possible interchangeability on any type of panel without affecting calibration.

CONVEYOR

Offers Extreme Flexibility of Operation

THE DEVELOPMENT of an entirely new type of conveyor, designed to handle bulk materials in a horizontal run-around path, within minimum headroom, is announced by Link-Belt Company. This "Sidekar-Karrier" provides conveyor storage for materials that are to be discharged simultaneously in varying quantities at a number of points.

The conveyor is self-feeding from any one of many feed spouts which may be located above its horizontal run-around path of travel, and self-discharging to any number of points, thus permitting continuous automatic operation. Any surplus material that is still left in the conveyor buckets after they have served the several discharge



Bucket conveyor for bulk materials

points will remain in the buckets, to be recirculated.

The design is such that two or more materials can be separately fed to the conveyor with the assurance that the admixture will not be disturbed in transit, and that it will be delivered to any predetermined discharge point in exactly the same mixed proportions as prevailed at the feed points. The conveyor spouts are self-cleaning.

FLOAT VALVE

Utilizes Mechanism of Tire Valve Core

FOR USES where a constant supply of fresh water must be maintained in pans or tanks, the new Simplex automatic water float valve fills a need for low cost, positive control of water level. It is designed for use by poultry men, stock men, pet fanciers, scientists, and experimenters, and for many household applications.

The valve body is turned from dural stock, anodized to prevent corrosion





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Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

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Inset: Tire valve for water control

under all conditions. The valve mechanism itself is an automobile inner tube valve core. Since these are stocked at all gas stations, cores can be readily replaced when necessary. The intake vent of the valve body is located above the settling line to prevent clogging. In addition, when the valve is opened, the end of the valve core needle extends slightly above the intake vent to dislodge scale or sediment.

FIRE-REPELLENT PAINT

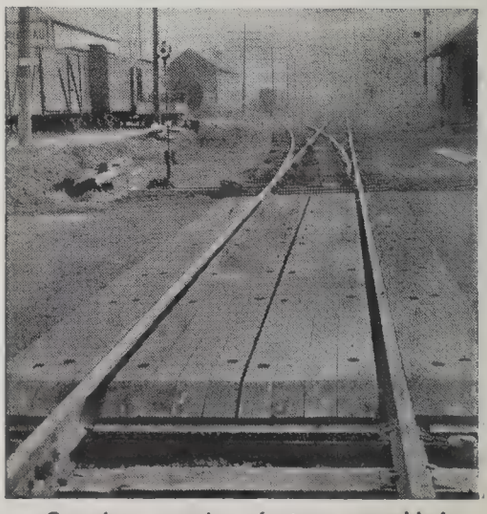
Reduces Hazard to Combustible Surfaces

A PAINT which protects wood and other materials against fire hazard, announced by the General Detroit Corporation, is endorsed by Underwriters' Laboratories and other leading testing bureaus for protection of interior combustible surfaces. Known as Fi-Repel, the new paint is made for use in factories, warehouses, hangars, garages, schools, hospitals, hotels, homes, and wherever else fire protection is necessary. It is shipped as a concentrated paste. After dilution it can be applied with a brush or spray gun to the surface to be protected. One concentrated gallon, at standard dilution, will cover as much as 185 square feet with two coats. Standard color is bone-white, but tints may be easily added.

GRADE CROSSINGS

Of Creosoted Wood Assembled in Factory

FACTORY-ASSEMBLED grade crossings of pressure-creosoted wood, ready for quick installation, are a new prefabricated product for the railroads. Com-



Complete crossing, factory assembled

plete crossings are constructed of select hardwood in panels about 2 by 8 feet and 5⅛ inches thick. The timbers are machined to proper shape, pressure-treated with creosote against decay, and tightly assembled into rigid panels with spiral dowels which grip along their entire length. This construction is said by its designers, the Koppers Company, not to be affected by vibration, swelling, or shrinking of the wood and to distribute highway wheel loads over the panel.

Individual panels are light enough to be installed by hand. They can be removed during track repairs and relayed without being damaged. For rails up to 110 pounds the panels are attached directly to existing ties. For rails 112 pounds or heavier, shims are attached between the crossing panels and the ties. Panels are attached to ties with lag screws.

PORTABLE LUBRICATION

Unit Speeds Servicing of Industrial Machinery

DESIGNED to provide a complete, compact, portable lubrication department for industrial plants, that can transport and dispense a variety of grades or types of lubricants, a new Lubrikart has just been announced by the Alemite division of the Stewart-Warner Corporation.

The new unit, mounted on five-inch ball-bearing casters, is only 21 inches



Complete, portable lubrication unit

wide. It is 31 inches long and 37½ inches high. Pushed like a perambulator, it is intended for one-man operation and is able to travel between rows of machines or elsewhere in a plant where space is limited.

The Lubrikart comes in two models, one of which carries two seven-gallon tanks equipped with low-pressure pumps and five and a half foot hose and non-drip nozzles for filling oil reservoirs on machines or hydraulic systems, and for filling gear housings; one seven-gallon tank with high-pressure pump for loading handguns; two one and three-quarter gallon tanks with oil transfer pumps for filling oil cans; six spout-type oil cans; and four lever-type handguns. There is also space for waste, replacement fittings, small tools or other material.

The second model has, in addition to the foregoing equipment, a high-pressure, hand-operated grease pump which holds 30 pounds of lubricant and has a five and a half foot lubricant hose fitted with a hydraulic coupler. This pump develops up to 7000 pounds of pressure per square inch, and can be lifted clear of the cart and carried to point of use, if desired. All pumps, loaders and transfers are manually operated.

HIGH SPEED PRESS

Molds Rubber Parts With Reduced Curing Time

RUBBER is now molded on a small high speed press by a new method utilizing an electronic heating device. The method, which is said to effect a substantial reduction in curing time compared with conventional equipment, is an offspring of the Baldwin Locomotive Works "Hyspeed" plunger molding press for plastics, announced some time ago.

The additional adaptation of the press for rubber provides economy of operation and maintenance, according to its designers. The press operates with a smaller number of cavities than are used in the conventional rubber molding presses. Yet, due to its high speed, it can produce the same number of products as larger conventional presses. Thus there is a savings in molds and maintenance, plus conservation of dies.

The new method is capable of molding all kinds of mechanical rubber goods, plumbers' supplies, and other items where cavity-molding is needed.

While this new method can be used without preheating the material, a still further increase in production may be obtained by using electronic radio frequency heating where possible. These radio frequency generators were developed by Westinghouse for use in conjunction with Baldwin's new press.

FERTILIZER

Made from Waste Of Plastics Plant

CONSTRUCTION of a non-profit ammonium sulfate plant to transform industrial acid waste into much needed fertilizer and designed to help reduce pollution of the Delaware River has recently been announced by the Rohm and Haas Company.

The waste materials came from the manufacture of Plexiglas, a transparent plastics. It was foreseen by research

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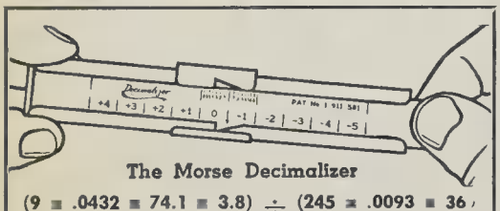
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chemists that Plexiglas would play an important war role, particularly in the aircraft field. Realizing that the acid residue from this manufacture might become a factor in river pollution, a research program was instituted on the utilization of the residue, resulting in the recovery plant now in operation.

A 300-acre farm which adjoins the plant property was the testing ground for the fertilizer, and hundreds of tons of this material are now being shipped to fertilize other farms in Pennsylvania, Delaware, Maryland, and Virginia.

Ammonia is the principal ingredient needed to convert this waste into fertilizer.

PYROMETER

Is Encased in Plastics For Better Illumination

EQUIPPED with a re-designed plastics case, the new Cambridge surface pyrometer is much easier to keep clean than the earlier metal-encased model and is corrosion free. The plastics case also simplifies electrical insulation problems and makes possible mechanical improvement.

In the new model an unbreakable Lucite window replaces the usual glass pane and extends over the top of the instrument, enabling the scale to be better illuminated and permitting more accurate temperature reading. These pyrometers are widely used to measure the temperatures of moving, still, flat, or curved surfaces in the rubber, plastics, paper, and metal working industries.

RUBBER STENCIL

Used in Stone Carving By Sandblast Method

THE WORK of inscribing names on headstones has been made easier by the development of a rubber sandblast stencil sheet. Until a few years ago the only way to do the job was for a skilled workman to cut the inscription with hammer and chisel. Then came the thought of stencils to make the work quicker and easier, but the difficulty was in finding a material tough enough to remain firm and whole under the high-pressure blast of the sand. After much experimentation, rubber was found to be the best material.

Such a stencil was developed by The B. F. Goodrich Company. It had to have many special properties. Not only did it have to be tough enough to withstand the blast of the sand, but it had to cut easily so that the stenciled lettering and designs would have smooth, sharp edges. It also had to have an adhesive surface on one side to adhere to the stone. Such adhesion had to be strong enough to hold tight and at the same time adhere lightly enough to strip cleanly away from the stone after the work was finished.

Before the war these stencil sheets were made of natural rubber. Now they are made of synthetic that is supplied in rolls of 50 yards, .051 inches thick. The stencils are being adapted to many other types of work.

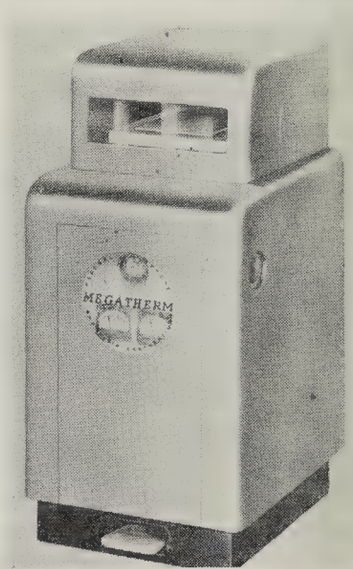


Sandblast stone carving is made simple by use of a removable rubber stencil

MEGATHERM

Has Detachable Oven Equipped with Window

PORTABLE and of compact design, a new Megatherm for high-frequency heating of a wide range of dielectric materials has been developed by the Federal Telephone and Radio Corporation. Contained in a modern streamlined reinforced steel cabinet, standing 42 inches high, this one kilowatt model occupies a floor space only 20 by 24 inches, and is mounted on smooth-running casters furnished with a special lock-down feature which secures the unit at any selected location. The detachable work oven is situated at the top of the cabinet, and is equipped with an inside light and window to permit the operator to view the work during the entire heating cycle.



Dielectric heater has oven on top

A foot-pedal switch opens the oven door, leaving the operator's hands free to insert the work in the oven. Application of power to the work is controlled by a simple single or double push-button located on either side of the cabinet. Duration of the heating cycle is controlled by a fool-proof automatic timer, permitting operation by unskilled and non-technical personnel.

The new Megatherm is suited for

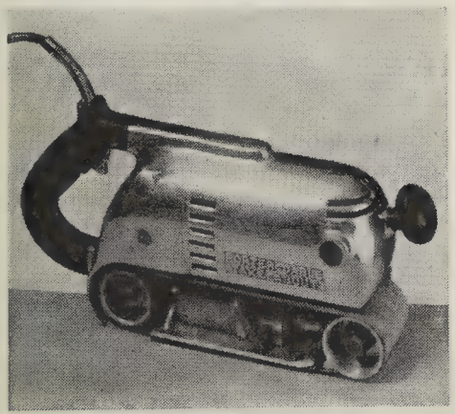
the preheating of plastics preforms, as a basic unit for incorporation into molding presses or into special production set-ups.

SURFACER

Increases Production by High Belt Speed

EASY to handle and light in weight, a new "streamlined" surfacing machine is designed for durability; its high speed provides faster surfacing.

The uses for these portable surfacers are almost unlimited. They are at work in metal and woodworking plants, pattern shops, maintenance departments, assembly lines, schools, boat building industries, and are being used for removing paint and refinishing numerous items, saving hand labor and with a



Light in weight for portability

speed that eliminates the use of many hands.

A three quarter horsepower motor drives the belt at a speed of 1600 surface feet a minute. Special features include: aluminum die cast frame; plastics handle; trigger switch in handle; and silent chain drive.

ROUGHNESS GAGE

Aids in Uniform Surface Control

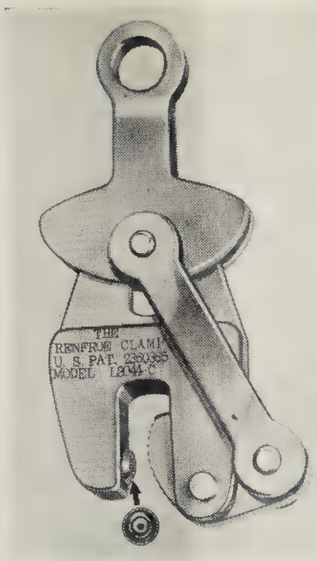
TO MAKE industrial surface control easier, a kit of roughness standards has been prepared with 20 replicas of machined surfaces bound in a 65-page educational text. The samples of machined surfaces were prepared by turning, grinding, milling, honing, lapping and polishing. They vary in roughness from 500 to 5 micro-inches. Made under the trade name Surf-Chek, the replicas are molded into a 5 by 7 inch plastics plate through the use of precise die inserts.

This new method of determining surface roughness eliminates guess interpretation, conveys the engineer's specific instructions to the machinist, and permits the making of rapid and efficient roughness comparisons without the need of special instruments.

CLAMP

For Lifting Steel Plate Has Safety Feature

AN ENTIRELY new clamp for lifting steel plate is now marketed under the name of Renfroe, by the Paul Henry Company. The use of a cable sliding through rings or guides to actuate the gripping cam is eliminated, which saves time required for inspection of cable. Through the action of the gripping cam shackle, the work is gripped



Cam shackle insures firm grip

instantly and firmly the moment tension is applied to the lift by the crane, even though the body of the clamp is in a horizontal position. The operator, therefore, does not have to hold tension by means of a cable, and stand in a dangerous position until the clamp starts to lift the work. In conjunction with the gripping cam, a swivel jaw is said to provide a deeper and more secure bite on the plate. Swivel jaw and gripping cam, and all other working or stationary parts of the clamp are readily replaced.

RESISTANCE WELDING

Reduces Air Drag On Planes in Flight

AN IMPROVEMENT in the method of fastening the skin of an airplane to its frame has greatly lessened the drag of air-flow over and around the plane. Instead of rivets, resistance welding is employed as the connecting medium, thus eliminating rivet heads. The sur-



Welding airplane skin to frame

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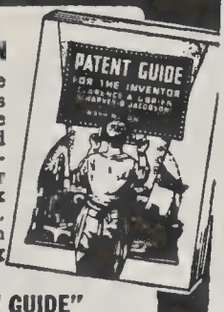
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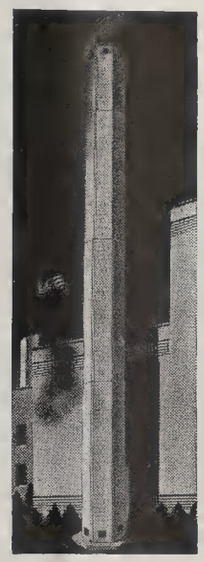
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face is left perfectly smooth, allowing unobstructed flow of air over the outside surface of the craft. Other important advantages accruing from the newer method are reported. For example, fittings can be made smaller and lighter, because of the closer pitch permitted in spot welds.

STEEL SMOKE STACK

Has Insulated Lining To Improve Draft

OFFERING many advantages, a new "Durabilt" smoke stack consists of a hexagonal steel structure, adequately braced throughout its length to resist high wind load, shock, lightning, and earthquakes. Horizontal and vertical members are attached to the steel structure and these support anchor and tile-retaining castings. Each tile forming the inner wall is individually retained. The outer tile is supported by means of channels at definite spac-



High efficiency insulated smoke stack

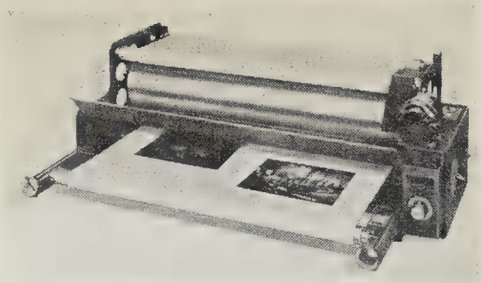
ings. Any section of tile may be independently removed without affecting the other.

Insulation fits snugly and securely between the tile and retainer castings, providing low radiation loss and helping to keep temperatures within the stack uniform, thereby increasing efficiency by improving draft. The outer casing of the stack can be of tile, sheet steel, Transite, or water-proof material. Air space is provided between the insulation and outer tile throughout the stack. Vents are located at bottom and top. The Chicago Fire Brick Company is the manufacturer.

PHOTO DRYER

Designed to Process Prints Speedily

Now available is a photo dryer which operates with additional electrical heating elements that assure maintenance of even heat. It quickly dries matte or semi-matte prints or glossy prints as well as blue or black-and-white prints. Thermostatic control may be had and variable speed drive motors and controllers permit instantaneous speed changes over a range of 6 inches to 3½ feet a minute.



Electrically heated photo print dryer

A chromium plated copper drum that finishes photos with high glossy surface is included. Steel-clad, refractory insulated, nichrome heaters, nickel contacts, and asbestos insulated nickel wire are used, forming a long-lived heating and control unit. The dryer, made by Peck and Harvey, comes in 26 inch and 44 inch widths.

NEW PLASTICS

Combined with Fabrics Make Strong Materials

A NEW family of liquid plastics has been developed by United States Rubber Company. Known as Vibron resins, the new materials, when combined with spun glass or other fabrics, have a great strength. Stronger building materials for prefabricated housing, stronger and lighter luggage, and lighter furniture impervious to dampness will, it is claimed, be possible by the use of these plastics. They will also permit reduced fabrication costs of numerous products because they do not require expensive and cumbersome equipment for their manufacture.

These resins may be combined with fabrics to make an improved type of artificial leather; with wood veneer to form decorative structural panels; and with paper for packaging materials. Decorative textiles may be treated to make slipcovers or other upholstery fabrics.

ELECTRIC SHEAR

Cuts Sheet Metal Accurately and Easily

LIGHT in weight and easy to operate, the Stanley No. 214 portable electric shear cuts 14 gage hot rolled steel and other sheet materials in proportion. First introduced for use in aircraft production, it has also proved its usefulness in many manufacturing plants and metalworking shops where sheet steel, aluminum, and galvanized iron are fabricated.

The shear has a simple blade motion that feeds in the work so that little



For quickly cutting sheet metal

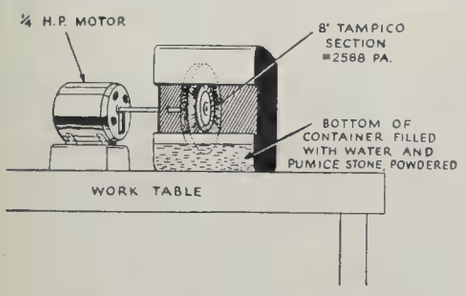
effort is required by the operator to cut straight lines, curves, angles, and notches accurately and without distortion of material. Blades can be removed easily for re-sharpening and replaced quickly. The duplex handle permits the operator to grip at a position most convenient for use.

POWER BRUSHES

Remove Excess Silver From Plated Watch Dials

Power brushing as a means of removing silver from watch dials following plating is enabling manufacturers to complete this operation in one sixth the time formerly required. Reports received from a Los Angeles watch dial manufacturer indicate that the use of power brushing in this operation is enabling watchmakers to accomplish more quickly the task of removing the excess silver from the dial without defacing or removing metal from raised numbers or other design figures.

Sand blasting, wire buff, or emery



Excess silver on plated watch dials is removed with a power-brush set-up

paper previously used occupied approximately three minutes per dial, it is reported. The operation is now completed in one half minute with power brushing.

The brush used, a product of the Osborn Manufacturing Company, is eight inches in diameter with an inside diameter of 3¼ inches and Tampico fibre sections approximately 17/32-inch in thickness. The dials are applied to the brush which is bench-mounted and operated by a one fourth horsepower motor. The buff revolves through a mixture of pumice and water.

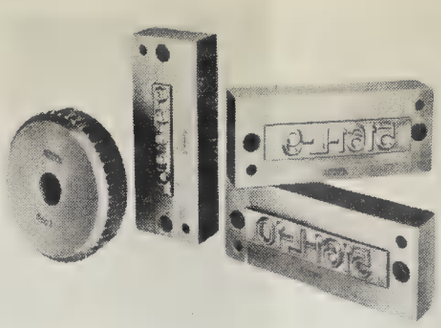
STAMPING DIES

Made with New Bevel For High Strength

Made from selected alloy tool steel, machined in such a manner as to utilize the "heart" of the steel where great strength is needed, and engraved with a new high-strength bevel, following the grain or flow of the steel, new stamping dies and roll dies are giving good results in hard service applications.

The roll die shown is for use in graduating scale bars used in the operating mechanism of a precision machine. By gearing with the slide carrying the scale bar as it is marked, the graduation markings are directed to the precision position required. The Acro-bevel die is so engraved as to withstand this gearing control.

The stamping dies shown are used in



Roll die and stamping dies

a press for full-depth sinking of the markings. Points of weakness in ordinary engraving are reported to be overcome by the technical advancement offered by Acro-bevel. In the case of a closed character or an unsupported part of an open character, for example, the new technique increases strength at that point to match the stress, thereby precluding premature breakage or wear.

CONDUCTIVE RUBBER

Tested With Simple Equipment

An easy method of determining whether any rubber V-belt, flat belt, hose, or other product is static conductive has been developed by technicians of The B. F. Goodrich Company, which recommends that all static conductive rubber belts be tested for conductivity at regular intervals of at least once monthly.

Static conductive rubber belts have proved valuable in many phases of war work, particularly in operations where a static spark might set off a fire or explosion. They also will have many other peace-time uses, including those on washing machines and other household appliances.

A simple assembly, using a five or six foot length of lamp cord with standard rubber socket plug, a two-watt neon bulb, two ordinary clamps or metal prongs, and two insulated handles can be readily constructed for the tests.

One of the wires of the cord is cut, the neon bulb connected in the circuit, the insulated handles installed near the end of each wire, and the prongs or clamps attached to the wires.

To make the test, part of the belt or other rubber product is moistened with water, leaving a dry section eight to twelve inches long between the moistened surfaces, the testing assembly is plugged into any 110-volt alternating



Testing conductive rubber belts

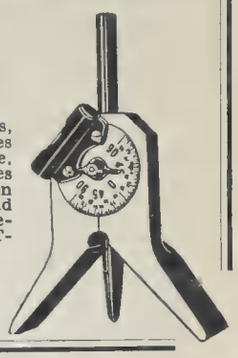
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current line, and the clamps or prongs applied to the moistened surfaces, with the dry section in the middle. If the bulb glows, the rubber product is a static conductor.

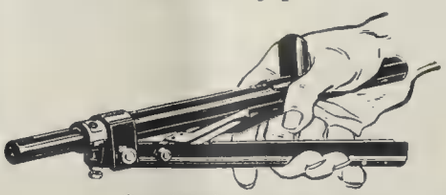
The belt or other article under test must be suspended in the air between the clamping points, or rest on a non-conducting table or other surface.

RIVET GUN

Operates With One Hand to Install Blind Rivets

COMPACT and light in weight, a new rivet gun, the G-35, is designed for installing Cherry Blind Rivets in hard-to-get-at spots. It is operated with one hand—installs the rivet from one side of the job, with a pulling force—and eliminates the necessity of a man on the other side of the rivet.

The G-35 has already proved its ease



One-hand rivet gun

and flexibility of use in such industries as aircraft, sheet metal, radio, marine, railroad, automotive, and furniture. It installs blind rivets in sheet metal, plywood, rubber, plastics, and almost any soft or brittle material.

The gun is small, compact, flexible, measures only 11½ inches in length, weighs approximately 1½ pounds, is well-balanced for easy one-hand operation. The pulling head is notched so that it snaps onto or off the gun quickly and easily, allowing greater gun flexibility and quicker head interchange for holding any standard Cherry Blind Rivet—aluminum, copper, or steel.

PRESSURE SWITCH

Cuts Electrical Circuits In Case of Fire

AN ACCESSORY device recently designed for use with built-in carbon dioxide fire extinguishing systems assists in isolating the fire by automatically cutting off electrical circuits in fans, blowers, or other electrical equipment when the extinguishing system operates. It is a self-contained, mercury contact-type switch suitable for applications which employ gas or air pressure.

The Kidde pressure switch is connected by a bleed pipe from the main distribution line and is operated by the carbon dioxide in passing through this distributing piping to the discharge nozzles. The gas pressure actuates a plunger which trips the breaker arm of the switch, opening or closing the circuits desired. The device is available for control of two, three, or four circuits, each of which may be wired for normally open or normally closed operation. The pressure switch is provided with a manual reset to restore circuits to their original position after operation due to fire.



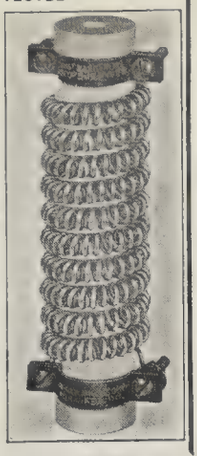
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Current Bulletin Briefs

Conducted by K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

THE INFLUENCE OF MODERN GLUES ON THE UTILIZATION OF WOOD is a 17-page booklet based on an address by W. F. Leicester, President, Casein Company of America, which covers the technique of gluing of wood, plywood, lamination, modern glues, various resins, plywood tubes, using wood with other materials, and so on. Request Bulletin SAA. *Casein Company of America, 350 Madison Avenue, New York 17, New York.—Gratis.*

THE DI-ACRO SYSTEM OF DIE-LESS DUPLICATING is a 40-page booklet based on the latest models of precision machines for this work, including the use of Torrington roller bearings in all sizes of Di-Acro benders for increased capacity and ease of operation. The universality of this system will allow the machines to be readily converted from war- to peace-time production. *O'Neil-Irwin Manufacturing Company, Minneapolis 15, Minnesota.—Gratis.*

WHAT MAKES A GREASE is a 12-page pamphlet which deals in general terms with the qualities that should be inherent in an industrial grease, as well as those factors to be considered in selecting grease for a specific application. *Sun Oil Company, Industrial Products Department, Philadelphia, Pennsylvania.—Gratis.*

HIGH-VOLTAGE TEST EQUIPMENT, BULLETIN F, is based on information about several forms of high-voltage test equipment; also resistors which are available separately for use with suitable meters to permit measurements of potentials up to 200 kilovolts. *Shallcross Manufacturing Company, Collingdale, Pennsylvania.—Gratis.*

HYSTER LIFT TRUCKS is a series of four catalogs based on the applications and mechanical specifications of a complete line of pneumatic-tire lift trucks, gasoline powered. *Hyster Company, Portland 8, Oregon.—Gratis.*

Z-METAL is a four-page folder giving interesting and practical information on Z-metal chain belts and their applications. One of the characteristics claimed is its remarkable resistance to corrosion. Request Bulletin Number 460. *Chain Belt Company, Milwaukee 4, Wisconsin.—Gratis.*

SAFE PRACTICES AROUND CIRCULAR SAWS, SERIES B, is a set of six charts, each one containing an illustrated "Do" and "Don't" to avoid injury from circular saws. These charts are useful for employee training, educational programs, mounting on bulletin boards, and reproduction in safety training manuals. This is one in a series of 12 sets of Industrial Safety Charts. *Superintendent of Documents, Government Printing Offices, Washington 25, D. C.—Five cents.*

WHEELCO ELECTRONIC CONTROLS is a 12-page catalog describing an electronic principle by which control is effected without contact between measuring and control units of an instrument. Many items supplied by the company are included in a convenient, condensed listing. *Wheelco Instrument Company, Harrison and Peoria Streets, Chicago, Illinois.—Gratis.*

OIL REFINING is a 32-page technical and economic study of the development of oil refining from an elementary physical operation a generation ago to its present scientific status as one of the major chemical industries. The importance of petroleum as a raw material is emphasized. Fluid-catalytic cracking, thermal cracking, suspensoid cracking, and other basic processes are described. *The M. W. Kellogg Company, 225 Broadway, New York 7, New York.—Gratis.*

KLEM KLEANERS is an eight-page folder based on a step-by-step procedure to acquaint personnel with cleaning, derusting, phosphotizing, soldering, and maintenance processes. A layout chart of the concentrations of the cleaners for specific work and conditions is given. *Klem Chemical Works, 1500-18 East Woodbridge Street, Detroit 7, Michigan.—Gratis.*

THE STORY OF MUSIC-AT-WORK is a 16-page brochure tracing the story of music at work from earliest times to the modern planned programs being used today. The findings of government and college research into the results of planned music in factories and plants are given. *Director of Sales Promotion, Executone, Inc., 415 Lexington Avenue, 17, New York.—Gratis.*

WIRE RECORDING is a booklet, written in question and answer style, which deals with the many possible uses for this economical way of recording sound. *Lear, Inc., Home Radio Sales Division, 230 East Ohio Street, Chicago 11, Illinois.—Gratis.*

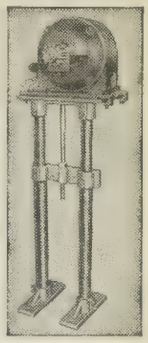
THE RADIAL ARM SAW WITH THE VERSATILE ELBOW is a descriptive circular announcing a saw which permits cutting a greater number of miters per hour than is possible with other saws and an attachment that affords three drill speeds, including 10,000 R.P.M. *Red Star Products Inc., 3455 Vega Avenue, Cleveland 13, Ohio.—Gratis.*

TEMPERATURE CONTROL CABINETS, Catalog 325, is a 48-page bulletin containing descriptions and photographs of various Freas constant temperature control cabinets and general information pertaining to mechanical and gravity convection heat transfer. *Precision Scientific Company, 1750 North Springfield Avenue, Chicago 47, Illinois.—Gratis.*

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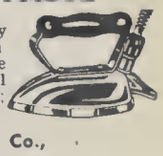
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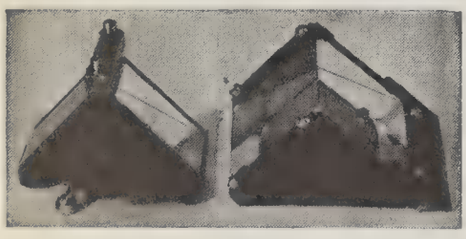
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Telescoptics

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THE large size of a 10.5 x 75mm richest-field binocular made, except the optics, by Henry Paul, 119 N. Broad St., Norwich, N. Y., is shown by comparison with the purchased 8 x 35mm binocular included in Figure 1. The big binocular has 3″ objectives and weighs 7 pounds. While it magnifies only 10½ diameters it has great capacity in revealing dim celestial objects.

Although this binocular has proved ideal for terrestrial use it was built mainly for astronomical observation. It is true, optical treatises point out that for astronomical use the added expense and labor represented by making and accurately mounting together two identical erecting telescopes, one for each eye, is not justified, and that the gains thus made are mainly psychological. For example, Bell, in "The Telescope," page 151, describes experiments which demonstrated that an increase of only 5 percent in magnification, if given to a monocular, was alone quite enough to bring its seeing power up to full parity with a binocular. Jacobs, in "Fundamentals of Optical Engineering," debates binoculars vs. monoculars, to the advantage of the monocular, where time and cost are prime factors. Paul concedes this for astronomical research but adds that "for the amateur it has been my experience that the ease of observation and the pleasure of viewing the skies are markedly increased by the addition of the second telescope."

Hardy and Perrin, in "The Principles of Optics," page 525, point out that binocular microscopes of the non-stereoscopic type also are growing in popularity because they give increased comfort. In any case, even a scientist (Paul is a nutrition chemist), when off the lot, sometimes finds it irksome to be too scientific, especially when equipped with a fully appointed shop (as he is) and possessed of the uncured itch to make fine things (Paul has made complete telescopes, all mechanically high-grade, Schmidt cameras including the optics, and acceptable roof prisms). "Although the optics of this binocular were purchased," he writes, "the mechanics of design, cementing and the rest, presented interesting shop problems.



Figure 1: Binocomparison

"The 3″ objective lenses," he continues, "are 15″ in focal length. The eyepieces, of 1⅜″ focal length, came in focusing mounts. Their field lenses are 1¼″ and their eye lenses 1″ in diameter. Four regular 1¼″ right-angled prisms were cemented in a suitable holder to form Porro's second system of erecting prisms (Figure 2), not the more familiar first Porro system used in the majority of binoculars. In this second system the faces of the four prisms are all cemented, excepting the two faces from which the light enters and emerges. This compact system has been used by Alvan Clark and by Zeiss in the familiar circular drum-

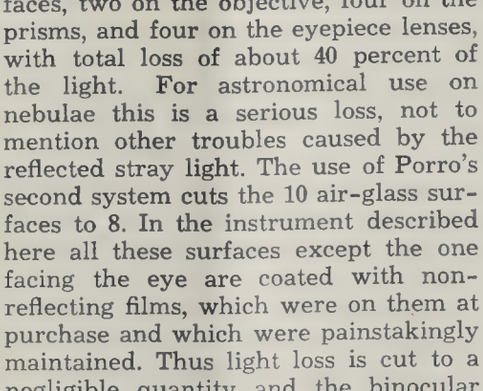


Figure 2: Porro's No. 2

shaped boxes between telescope and eyepiece. For a binocular, two of these prism units are required. One of them *must be reversed*, the mirror image of the other.

"The light absorption of the 4 to 5 inches of modern prism glass in these erectors is not serious. An ordinary binocular usually has ten air-glass surfaces, two on the objective, four on the prisms, and four on the eyepiece lenses, with total loss of about 40 percent of the light. For astronomical use on nebulae this is a serious loss, not to mention other troubles caused by the reflected stray light. The use of Porro's second system cuts the 10 air-glass surfaces to 8. In the instrument described here all these surfaces except the one facing the eye are coated with non-reflecting films, which were on them at purchase and which were painstakingly maintained. Thus light loss is cut to a negligible quantity and the binocular becomes a highly practicable and pleasing richest-field instrument, free from stray light and ideal for faint nebulae.

"Adjustment of prisms and lenses in binoculars must be made with great care, else double images will result. Were the prospective maker not fully informed of this in advance he might well agree with those who claim that binoculars are not worth the effort.

"Scrap magnesium, aluminum, and duralumin were used throughout, helping to reduce the weight to 7 pounds. A similar commercial instrument weighs 18 pounds. The glass of the large lenses and prisms contributes a large percentage to the 7 pounds, and its weight cannot be reduced.

"Materials cost less than one tenth

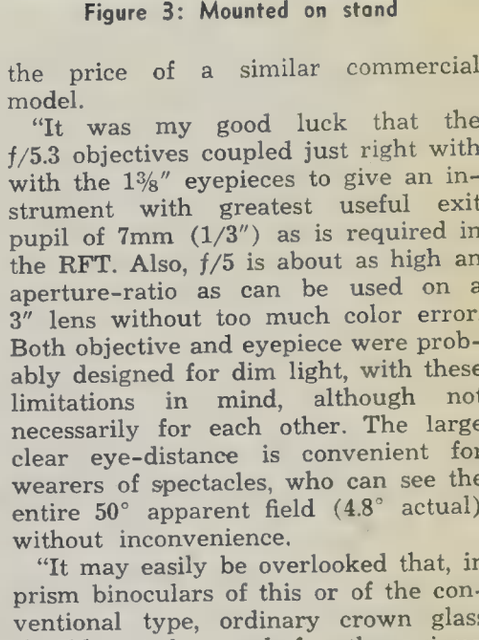


Figure 3: Mounted on stand

the price of a similar commercial model.

"It was my good luck that the *f*/5.3 objectives coupled just right with with the 1⅜″ eyepieces to give an instrument with greatest useful exit pupil of 7mm (1/3″) as is required in the RFT. Also, *f*/5 is about as high an aperture-ratio as can be used on a 3″ lens without too much color error. Both objective and eyepiece were probably designed for dim light, with these limitations in mind, although not necessarily for each other. The large clear eye-distance is convenient for wearers of spectacles, who can see the entire 50° apparent field (4.8° actual) without inconvenience.

"It may easily be overlooked that, in prism binoculars of this or of the conventional type, ordinary crown glass should not be used for the prisms. These should be of light flint glass. The high aperture-ratio of the objective results in a steep cone of rays that exceeds the critical angle of ordinary low-index crown glass. (Of course, the hypotenuse of a crown glass prism could be silvered, but then it would no longer be totally reflecting, as theory and experiment demonstrate, though it would have the index of reflectivity of silver, about 95 percent.) Prisms may be checked closely enough for this purpose with a ten-cent protractor and a straight stick, by viewing a bright area such as the sky through the optical axis of the prism and noting how many degrees the eye may be moved away from the axis in the direction of the other prism face before the critical angle is reached. This is plainly indicated by a line of coloration. This angle is reached at 5° or 6° for ordinary crown, while light flint gives a reading up in the 10° range.

"A stand (Figure 3) was a great convenience with this binocular because of the weight and because it i

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TO THE amateur telescope maker glass is the normal material for grinding tools, while the use of metal for such tools seems abnormal. To the professional the reverse is the case. The key to this apparent anomaly is that, when

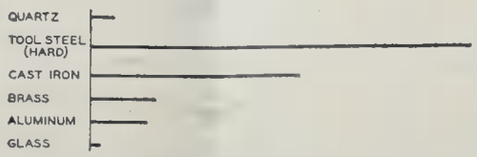


Figure 4: Relative resistance

only one job is to be done, it doesn't pay to make a metal tool even though the metal tool would be worn away less — for the wear on the glass tool will not greatly matter. An incidental dividend is the fact that the glass tool won't be so likely to scratch as a metal tool, into which abrasive particles tend to become imbedded and fixed.

Just how much less metal tools wear away than glass, also crystal quartz (note: not fused quartz) is the subject of quantitative researches made at the Bell Telephone Laboratories by W. L. Bond, a physicist, and described in the *Bell Laboratories Record*, Volume 22.

Figure 4 summarizes the findings quantitatively; it shows the relative resistance to abrasion of the six materials tested, when used against a cast iron tool. The author says: "It will be seen that the four metals have much greater resistance to abrasion than the quartz or glass, and that the resistance is of the same order as the hardness. The very soft aluminum, however, wore 2½ times as well as quartz, and yet on the Moh scale (of hardness) aluminum ranks 2 while quartz ranks 7. This is explained by the toughness of aluminum and the brittleness of quartz. The abrasive particles bury themselves deeply in the aluminum without removing pieces of the surface, while the brittleness of quartz enables the abrasive particles to break off small pieces, and thus the wearing away is faster. Glass, which is softer than quartz, and even more brittle, wears away still faster."

TWO Seattle, Washington, amateurs, Leonard Hughes, 810 E. 60th St., and R. V. Tomlinson, 8807 Roosevelt Way, made the 8" reflector shown in Figure 5. They write:

"The whole contraption was completed in less than four months of intermittent spare-time work (or should we say play?). The *f*/10 mirror is of Pyrex and the customary amount of grief was encountered in its manufacture. The tube consists of nine pieces of ¼" galvanized water pipe thrust through eight cast aluminum rings of 9" inside and 11" outside diameter. The thickness varies from ½" to ¾".

"The declination axis consists of two aluminum castings 5" in diameter with two machined faces held together by a double roller bearing and bolt and in such a manner that *a bearing surface the full diameter of the axis* is obtained [italics by the editor].

"The polar axis consists of a cast aluminum cone revolving in a cast aluminum cone receiver. The cone is held in contact by the axis, which is thrust into a small Timken bearing at the lower portion of the polar assembly.

"The castings were made by the general directions in 'A.T.M.A.'. The melting was done in an ordinary coal furnace with plenty of draft and coal.

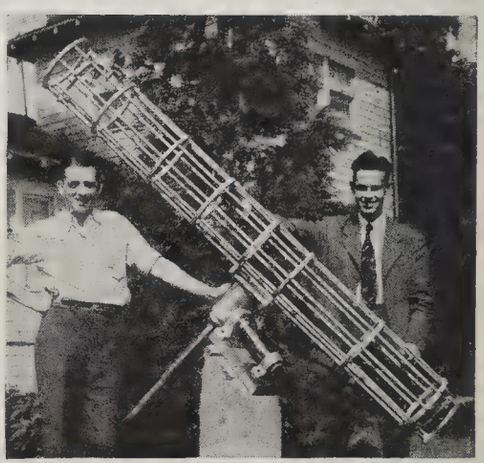


Figure 5: Tomlinson, Hughes

Best results were secured with a 20 percent mixture of foundry clay in fine sand. Trouble resulted if the molds were not dry; and it often resulted anyway.

"There is a total of 16 major castings in the mounting and tube. All casts were made in open mold, which greatly simplified matters.

"We plan to add setting circles, motor drive, and precision focusing mount.

"The whole telescope cost only $60 plus barrels of sweat.

"After the war we plan a 20" reflector of *f*/7 for photographic use. also a 4" photographic apochromat and a camera to match for a patrol of novae."

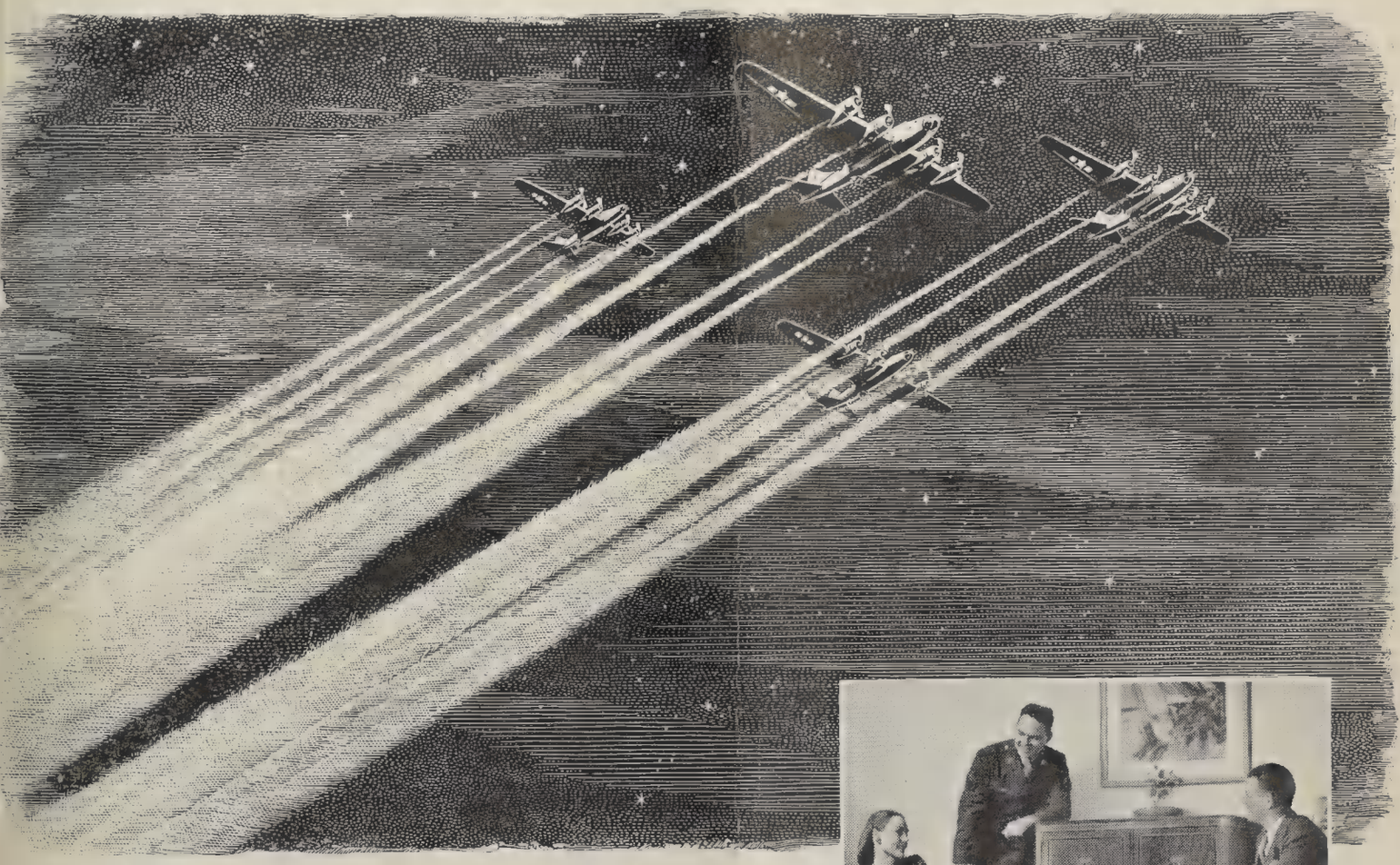
RELATIVELY few telescope descriptions have been coming in of late, yet "A.T.M." and "A.T.M.A." have increased in popularity each year throughout the war. These apparent contradictions seem to say that amateur telescope makers have been busy in war work, also have been unable to obtain materials; but that they are doing a lot of reading and planning for a revival of activity post-war.

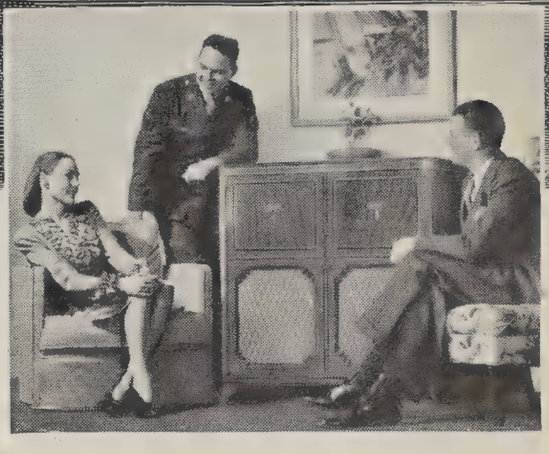
WE DISCOVER that the names of two producing members of the amateur Roof Prism Gang were omitted from the summary in last November's number. C. S. Walton, 5975 W. 44th Ave., Wheatridge, Colo., and Anton Bohm, 6815 W. 29th Ave., Denver, Colo., made 488 roof prisms.

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Optical Glass at 2200 Degrees, Fahrenheit . . . See page 130

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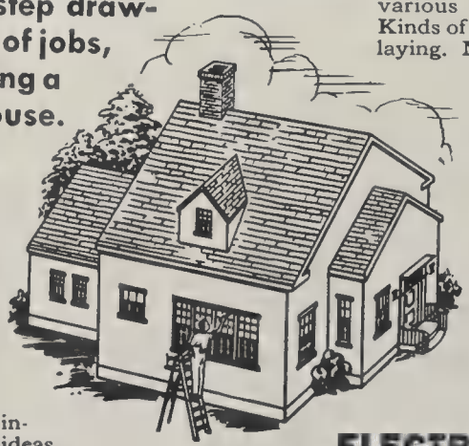
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Previews of the Industrial Horizon

RESEARCH TOMORROW

By A. P. Peck

MUCH in the news these days is the subject of scientific research and its application to industry in the future. In November of 1944, President Roosevelt asked Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, to make recommendations regarding ways in which scientific knowledge can best be made available to the world, ways in which the Government can aid research activities of public and private organizations, and ways in which scientific talent of American youth can best be promoted to assure the future of scientific research.

In July of this year Dr. Bush transmitted his thoughts, and those of a number of distinguished committees who collaborated with him, to President Truman. The complete report, presented under the title "Science, the Endless Frontier," should be read by every business man in the country. It is thorough-going and pains-taking in detail, and the general tenor of the whole report can be sounded by quoting the following paragraph from it:

"The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research, and to aid in the development of scientific talent. In addition, the Government should provide suitable incentives to industry to conduct research, (*a*) by clarification of present uncertainties in the Internal Revenue Code in regard to the deductibility of research and development expenditures as current charges against net income, and (*b*) by strengthening the patent system so as to eliminate uncertainties which now bear heavily on small industries and so as to prevent abuses which reflect discredit upon a basically sound system. In addition, ways should be found to cause the benefits of basic research to reach industries which do not now utilize new scientific knowledge."

In other parts of the report, some may find implications of proposed socialization of research activities. If this be true, then industry must beware. Governmental red tape, the lack of incentive bred of bureaucratic sinecures, and the tendency toward playing politics on the part of governmental employees are not at all conducive to progressive and aggressive research of the type that has placed American industry in its present enviable position.

Whatever implications may be read into the report rendered by Dr. Bush, it should be encouraging to note an increasing realization in all quarters that industrial research is *necessary* and that it must be pressed forward at all cost if the nation as a whole is to prosper. But it must not be forgotten that a vast proportion of the research which has made our nation what it is today has stemmed directly from industry itself, fostered by what some people still sneeringly refer to as the profit motive.

The profit motive has its faults, it is true, but it has built in the United States the most powerful industrial nation in the world. It has reduced mass-production — with its attendant material benefits — to almost an exact science. At the same time it has made possible, directly and indirectly, much of the pure or fundamental research which has contributed so largely to cultural progress — and which, in turn, has completed the cycle by contributing in large measure to the furtherance of private industry and of the same profit motive that gave it birth.

We think that a brighter side of the whole subject of the future of research lies in the recent announcement by General Motors of its Technical Center where post-war research in all its aspects will have the objective of providing more and better things for more people. Here is a promising view of a not too distant horizon where one segment of one industry will work toward providing an economy of plenty that will benefit not only its own selfish profit motives but will spread these benefits over the whole face of the nation and of the world.

What this one segment of one industry can do, under the American profit system, every other segment of every other industry can do, each in proportion to its size and potential productivity. If each segment does its own share, the total aggregate will eventually equal and surpass even the enormous possibilities of Government-sired and Government-sustained research. And the incentive that goes with private industry will be there, ever spurring onward toward greater accomplishments.

BELTS CAN CARRY IT

FORWARD-LOOKING engineers see on the horizon a time when conveyor belts will do a far greater number of jobs than they are doing today. In coal and copper mining, belts large and small have proved themselves; in coal mining, belts are making serious inroads on the electric locomotive method of handling coal. It is estimated that today more than a million and a half feet of belting is used for this work but even this vast footage handles only a small fraction of the coal production of the nation. So satisfactory are the belts, however, that it is predicted that, within a few years, 80 percent of the coal mined underground will be removed from the mines on belts.

But the surface of the conveyor-belt business has just been scratched. Belts are being used increasingly to transport raw materials in factories, and this phase will increase in importance as possibilities are explored more thoroughly. In the meantime, engineers are again toying with the idea of moving people from point to point on belts. If the bugs can be worked out, and the people can be adequately protected against accident, this transportation method should have great appeal, particularly for moving passengers from waiting rooms to planes and trains, workmen from parking lots to their benches, and the like.

FACSIMILE

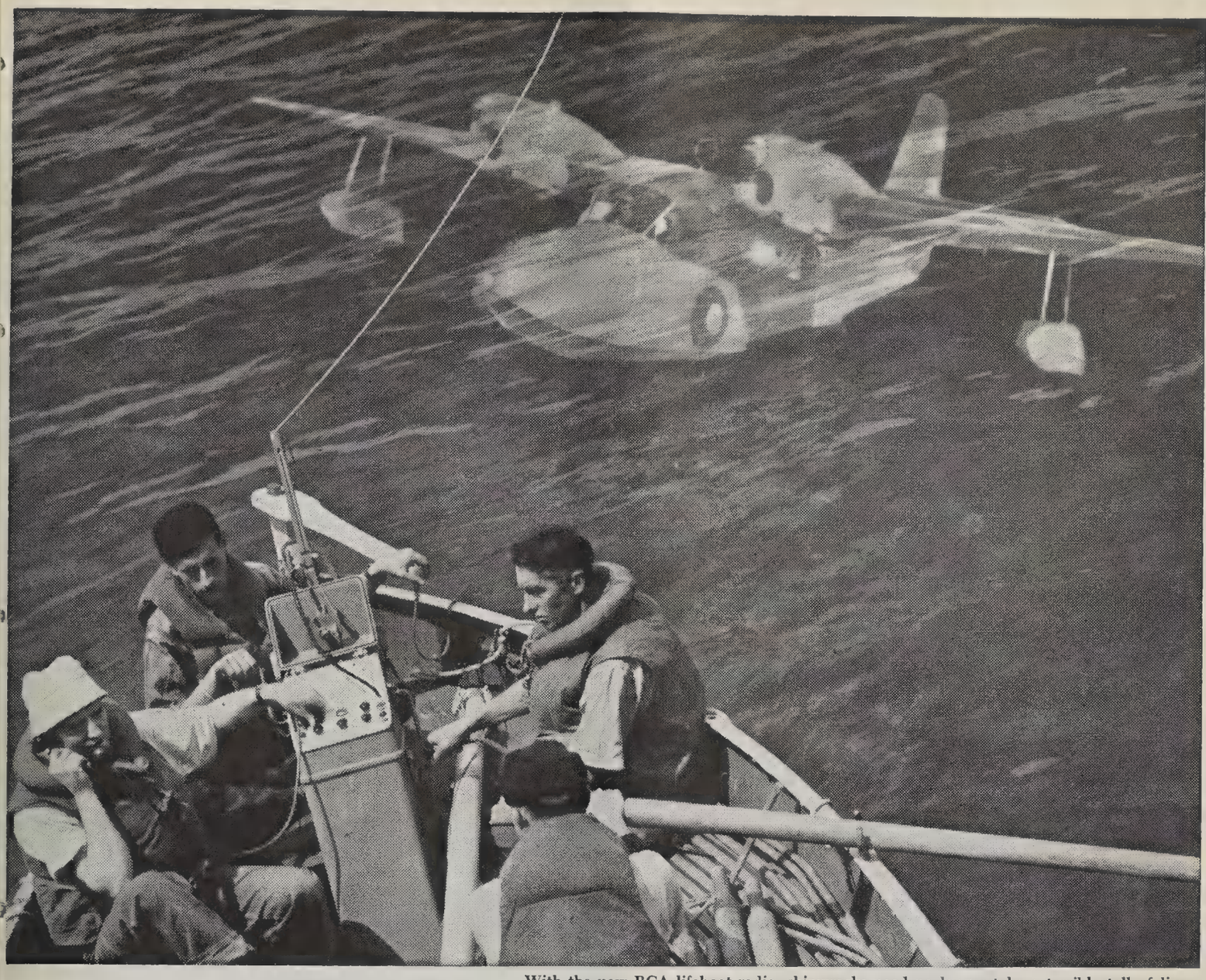
ONE OF THE oldest forms of communication by electricity is facsimile, in which an exact copy of a message, picture, complicated sketch, or what-ever is reproduced at a point distant from the transmitter. However, technical difficulties have beset the paths of facsimile engineers, with the result that, despite earnest effort, success was slow in coming. Facsimile, offering advantages of highly accurate transmission, extreme speed, and a permanent record of the communication, has received great impetus during the war. It has been used to send maps, orders, photographs, and other military information by wire and radio.

Facsimile differs from wire-photo methods of communication in that facsimile builds up a copy at the receiver by direct electrical action on paper; in wire-photo the receiving action is photographic and a darkroom and attendant equipment are required.

Present plans for the future of facsimile include units for inter-office communication and for attachment to home radios. The latter, of course, presupposes a transmitting set-up that would make ownership of a home facsimile unit desirable.

FOR FUTURE REFERENCE

A HOME dishwasher, to sell for about $75, is reported to be ready for near-future manufacture . . . Complete, assembly-line-built houses of three rooms and bath, that will sell for $2000 or less, are being made in a Goodyear pilot plant . . . Link these houses with "prefabricated" dinners, on plates that are designed to be used and thrown away; meat and vegetables, tastefully arranged, are partially cooked, then frozen; just heat and eat.



With the new RCA lifeboat radio, shipwrecks need no longer take a terrible toll of lives.

A two-way radiophone—for lifeboats!

Here's when a telephone comes in rather handy . . . when you can "get your party" and hear "We'll be there to get you in a couple of hours!"

With the new RCA compact lifeboat radio, that's exactly what happens. A kite, or a balloon, takes the antenna up 300 feet.

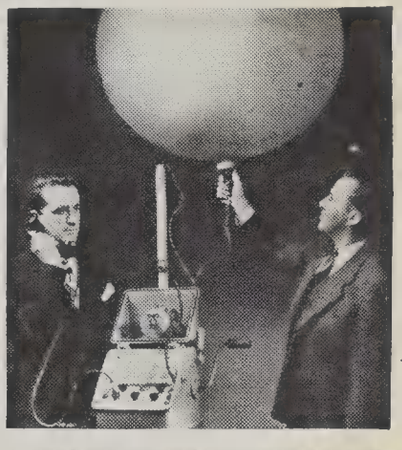
Turn the power-generating cranks and out goes an SOS—along with a direction-finder beam so shore stations can figure your exact location.

But even more amazing, shipwrecked mariners can talk with the men on their way to the rescue. They can "pick up" ships, airplanes, and that wonderful place called "land"—even if it's 1000 miles away!

Endless research, such as went into developing this lifeboat radio, goes into all RCA products.

And when you buy an RCA Victor radio, or television set or Victrola, you enjoy a unique pride of ownership in knowing that you possess one of the finest instruments of its kind that science has achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20. ▪ *Listen to The RCA Show, Sundays, 4:30 P.M., E.W.T., over the NBC Network.*



Joseph McDonald and Donald Knlb (holding balloon) are the Radiomarine engineers who developed this lifeboat radio. Here is the balloon that is inflated with helium and carries the antenna as high as 300 feet into the air.

RCA **RADIO CORPORATION of AMERICA**

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of September, 1895)

NIAGARA POWER — "After almost five years of work and the expenditure of over $3,000,000, Niagara Falls are now being utilized for power. The monster 4,000 horse power dynamos of the Cataract Construction Company are now sending out electricity for commercial use. The first power was delivered to the works of the Pittsburgh Reduction Company at 7:30 o'clock, August 26, when dynamo No. 2 in the construction company's power house was set in motion. At the reduction company's works there were about a dozen men at work and the pots used in the making of aluminum are being tested by them."

FORESTRY — "Farmers throughout the United States are making a mistake when they fail to plant trees on all their land not suited to crops, and along their lanes, fences, and highways. Without any other expense than that of planting the young trees they could provide for fine rows of maple, oak, pine, birch, hickory, walnut, and other trees on their farms, all of which would be increasing in value every year."

FREIGHTER — "The twin screw White Star steamship Georgic, Captain Smith, finished her maiden trip to this port, August 26. She is the biggest freighter in the world, and probably the swiftest, being able to make thirteen and a half knots. She was built at Belfast by Harland & Wolff, and measures 10,077 tons. She is 538 feet long, of 60 foot beam, and 40 feet deep."

TRANSPORTATION — "The whole of the tonnage on the oceans of the world last year was about 140,000,000 tons, while the tonnage of the railways of the world, carried 100 miles, was about 1,400,000,000 tons. There are 400,000 miles of railroad in the world, of which 180,000 are in the United States. Of the 1,400,000,000 tons carried 100 miles last year on the railways of the world, 800,000,000 tons were carried on the railways of the United States."

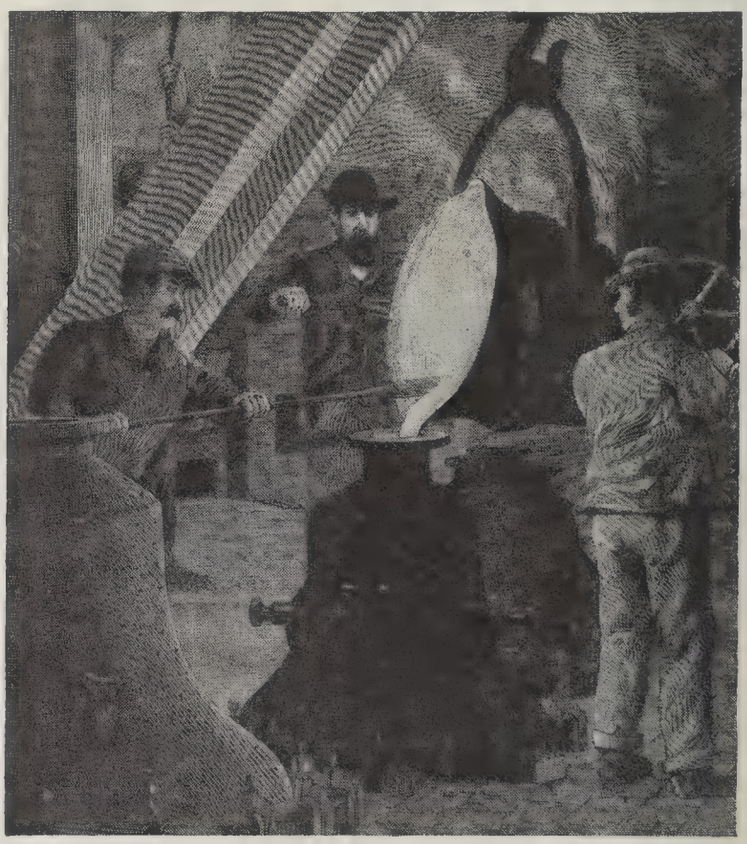
SOUND STUDY — "Voice analysis is recorded by making a resonator for the fundamental and overtones so as to sound in sympathy, and to cause tiny gas jets to flicker. These variations have hitherto been drawn by hand, but now they are photographed by a swiftly moving camera, so as to make a perfectly accurate record. Practically this invention is very useful in analyzing the voices of singers or speakers, and determining at once where they need improvement."

INVENTION — "No better examples of the importance of small things can be found than among the records at the United States Patent Office, in Washington. There are to be seen certain small objects which, by a lucky turn of affairs or, perhaps, by the ingenuity of the inventors, have become known throughout the world, and have been the means of filling the pockets of both the inventors and their representatives. In fact, it would seem as if inventors of small objects have sometimes been far better paid than skilled mechanics and engineers who have spent months and years in perfecting elaborate mechanisms."

WOOD PULP PINIONS — "The great development of electrical mechanism during the past few years has caused engineers and mechanics to give special attention to anything connected therewith. It has been found that an objection to nearly all electrical power apparatus is the extensive vibration of the gear wheels, which in almost every instance revolve at a higher rate of speed than in ordinary machinery. . . . Compressed rawhide pinions and cogs made from same material have been adopted with some success. Even this material, however, has its drawbacks, all of which are claimed to be done away with by combining wood pulp with the same."

FRUIT IN GLASS — "A new vacuum process of canning fruits in glass has lately been introduced from Europe among the packers of the Pacific coast. . . All the deleterious gases generated in cooking the fruit, and even the air, are extracted under this new process, so that fermentation is reduced to a minimum."

BELLS — "Church bells are, with but little variation, made of copper and tin, in the proportion of copper 78 parts, tin 22 parts. Bell founders claim that all additions of gold and silver, etc., are of no practical value. . . The flasks whereon and wherein the mould is made consist of two parts, constructed of boiler iron, of a general bell form, and plentifully perforated with holes for escaping gas while casting, one being so much less in size than its fellow as to give space for the loam forming the mould between the two. No 'pattern,' as the term is generally used, is provided. The two parts of the mould are 'swept' by 'formers,' accurately finished from thin iron to the form intended for the inner and outer surfaces of the bell. . . The melted bell metal being ready, the furnace is tapped, the bright stream caught in a huge ladle swung over the mould by a crane and poured into



the open mouth of the mould till it is filled. . . After cooling and removal from the mould, the bell is usually polished with sand and water in special revolving grinding machines."

FIRE-CYCLE — "The New York Fire Department has under consideration the construction of a bicycle chemical engine for use in the up-town and suburban districts. The plan proposed contemplates a light chemical engine of from 30 to 40 gallons capacity, which will be propelled by four men, which would make much better time than the horses do. Out of 1,100 men in the fire department, 300 now ride bicycles."

ROADS — "The total length of the common roads in this country, good, bad, and indifferent, is estimated by Gen. Stone, of the Road Bureau of the Department of Agriculture, at something over 1,300,000 miles. The majority of these roads have been opened by common laborers hired by county supervisors, and no engineering principles have been observed in their construction. As a result, it costs more to keep them in repair than if they were so many finely macadamized roads."



THE BIRD WITH THE 16-MILE TAIL

The wire you see with the parachute on the end of it is a telephone wire, being payed out from a C-47 cargo plane.

Bell Telephone Laboratories, working with the Air Technical Service Command of the Army Air Forces, developed this idea. It will save precious lives and time on the battlefield.

A soldier throws out a parachute with the wire and a weight attached. The weight drops the line to the target area. From then on, through a tube thrust out the doorway of the plane, the wire thrums out steadily — sixteen miles of it can be laid in 6 2/3 minutes. Isolated patrols can be linked quickly with headquarters. Jungles and mountain ranges no longer need be obstacles to communication.

This is in sharp contrast to the old, dangerous way. The laying of wire through swamps and over mountains often meant the transporting of coils on the backs of men crawling through jungle vegetation, and in the line of sniper fire. It is reported that in one sector of the Asiatic theater alone, 41 men were killed or wounded in a single wire-laying mission.

Bell Telephone Laboratories is handling more than 1200 development projects for the Army and the Navy. When the war is over, the Laboratories goes back to its regular job — helping the Bell System bring you the finest telephone service in the world.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for the Armed Forces at war and for continued improvements and economies in telephone service.



The Research Laboratory of the Libbey•Owens•Ford Glass Company in Toledo.

THIS IS WHERE WE TEACH GLASS TO DO NEW THINGS

If visibility were the sole purpose of glass, achievements of past decades in producing glass that is flatter, clearer and freer from imperfections would be enough—and scientists in the glass laboratories could rest on their laurels.

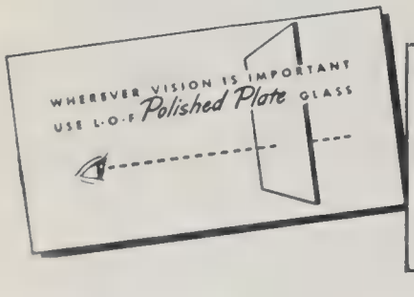
But engineers saw in glass far greater potentialities, far more benefits than those resulting from its ordinary uses. And so they found ways to make glass do new jobs—and do old jobs better. Their efforts have made glass more versatile than is commonly realized.

Could glass be made to withstand great thermal shock, impact and heavy loads? It could . . . and out of the laboratories came Tuf-flex, the L·O·F tempered glass of amazing strength.

Would it be possible to have window walls to "open" rooms to sunshine and view without excessive heat loss? It was . . . and L·O·F developed Thermopane, the hermetically-sealed, multiple-pane, glass insulating unit, suitable for all building types.

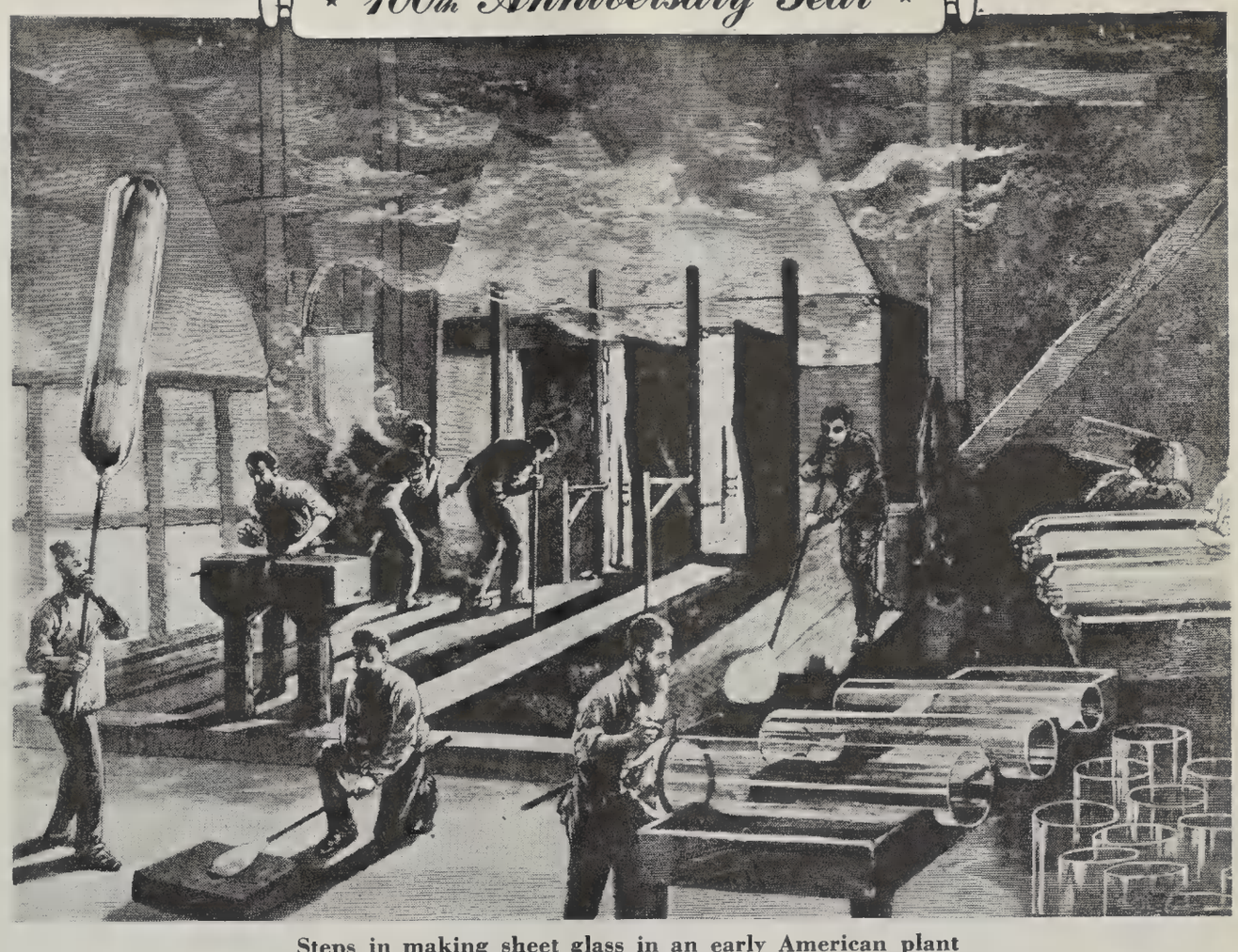
Could glass be made to let in daylight, yet block out most of the infrared rays of the sun? Now it's an actuality—L·O·F Heat Absorbing Plate Glass. *A glass to reduce fading?* Yes, L·O·F Golden Plate. *Glass in special shapes?* L·O·F has moulded thousands of bends. *Glass in transparent and opaque colors?* Yes, a wide variety of colors for unusual decorative effects. *Even laminated glass?* L·O·F has laminated millions of square feet of glass with plastic, producing Safety Glass for motorcars, planes, trains and ships. These and many other modern glasses typify the industry's progress.

Research has improved glass through the years, broadened its services and pointed to better things ahead. Glass technology has never stood still . . . and never will. Libbey·Owens·Ford Glass Company, 3095 Nicholas Building, Toledo 3, Ohio.



LIBBEY·OWENS·FORD
a Great Name in GLASS

Scientific American
SEPTEMBER • 1945
★ 100th Anniversary Year ★



Steps in making sheet glass in an early American plant

Light and Progress

By JEROME CAMPBELL and A. P. PECK

Glass, Material of Many Uses, Has Extended Man's Sight Into the Far-Off Universe and Into Microscopic Worlds. At the Same Time it Has Served Utilitarian Purposes in the Home and in Industry. Strangely Enough, it Was One of the Last of Present-Day Materials to be Adapted to Mass-Production Methods and Hence Put to Wide Use

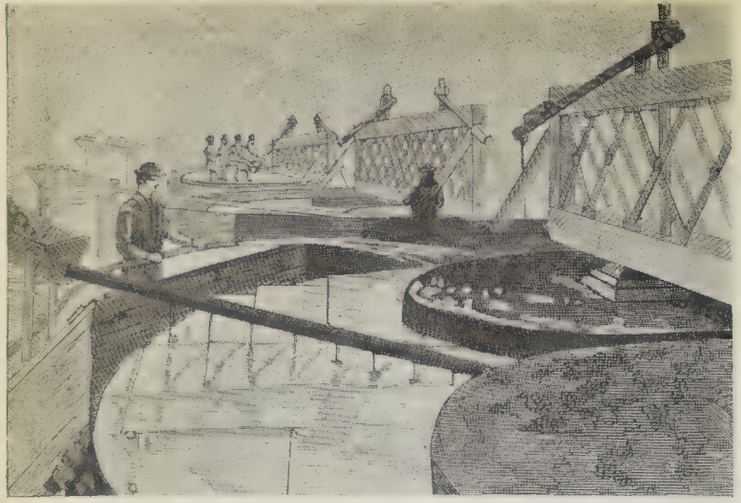
To SHELTER his body from the rigors of climate, man has had to erect walls around him and build a roof over his head. And glass, man's creation, allows him to admit light into his dwellings, while maintaining the protection of his shelter.

But glass does far more than this. To impaired eyesight glass brings vision so that the printed word is made clear. Glass made into telescope lenses and mirrors opens to man the enormous vistas of the heavens and makes known to him the complexities of outer space.

In an opposite direction glass also enriches man's understanding. Cunningly made into microscope lenses it reveals the swarming life too small by far to be seen by his unaided eyes. Bacteria and other micro-organisms, causes of death-bringing ailments and also sources of strength and health, are observed by him. By means of glass he learns how to check the harmful power of these organisms, invisible to the naked eye, and how to make use of their power to do him good.

When man began to make glass no one knows. Pliny offered the plausible explanation that it was discovered accidentally by the fusion of sand and soda in cooking fires. Whether this is true or not, it was during the great civilization of ancient Egypt that the making of glass, first as a glaze on pottery and later as a translucent and transparent material, emerged among human activities as an art and an industry.

The invention of the blow pipe sometime near the



Grinding plate glass in the 1880's. The rough plates, trimmed to best advantage, were mounted in plaster of Paris on the revolving table of the grinding machine

beginning of the Christian era, probably by Phoenician glass workers, enlarged the scope of glass-making greatly. It stimulated the development of clear transparent glass, and glass blowing became a great industry in the leading cities of the Roman world during the first four centuries of the Christian era.

Skipping over the development of stained glass windows, the famous Venetian glasses, and so on, it is found that during the 17th Century important progress was made in the manufacture of glass. In 1612, Neri published in Florence his work on glass technology, *L'Arte Vetraria,* translated into English in 1662. It was the first work on the chemistry of glass and has since come to be one of the classics of glass technology. It served as a source of information that contributed to the progress in glass making during the next hundred years.

The craft of glass cutting was greatly improved in the early years of the 17th Century by Caspar Lehman and his follower, Schwanhardt. An Englishman, George Ravenscroft, made an important contribution to glass technology by inventing flint glass in 1675. He used lead oxide to give this glass its features of great brilliancy and relative softness that make it adaptable to forming and decoration. An additional important step forward in glass manufacturing was taken in 1688, this time in France, when Louis Lucas invented the process of casting glass.

The 18th Century, the great "age of enlightenment," was marked by intense intellectual activity that bore fruit in advances in thought and in politics, culminating in the New World in the establishment of a free United States, and in Europe in the French Revolution; it was also marked by the development of optical glass. This the world owes to Pierre-Louis Guinand, a Swiss (1748-1824), who in 1790 worked out a method of producing it. He and his descendants found that by stirring the molten ingredients, and by annealing the glass, they could produce an optical glass substantially free from the imperfections that impair refracting qualities.

Guinand and his sons established a dynasty of optical glass makers whose activities spread from Switzerland into Germany and France. One of Guinand's great-grandsons, Edmond Feil, in 1893, set up an optical glass plant in America at Lenox, Massachusetts, and attempted to build up a business, but without great success.

AMERICAN GLASS—Although the production of optical glass in the United States did not get started in a large way until World War I abruptly cut off imports from Europe, the manufacture of glass for utensils, ornaments, and windows was actually the first industry set up by the English settlers in the new world. Among the first 70 passengers brought to the settlement of James Towne in 1608 by Captain Christopher Newport, at the instigation of the London Company, were eight Dutch and Polish glassmakers. A glass manufactory was established and some of its products were among the first exports from America in 1609.

The main job of the glasshouse in James Towne was to manufacture window lights for the colonists' houses. The venture seems to have failed shortly afterwards. Nothing more is heard about glass manufacturing in Virginia until 1621, when the London Company again tried to establish the manufacture of glass in its colony. In that year six Italian artisans were shipped across the Atlantic to make colored beads and similar gewgaws for trading with the Indians. Thus the second glasshouse established in America was also its first mint, for the glass manufactured for trading with the Indians was, in effect, currency. This glass-making attempt lasted until 1623 and then collapsed. It passes at this point in time from the pages of history into oblivion.

The next attempt at glass making in America was made in 1641 when Obadiah Holmes and Lawrence Southwick constructed a plant in Salem, Massachusetts, where it is believed they made window panes, bottles, pitchers, and lamps for a few years.

Some years later the Dutch in Nieuw Amsterdam set up a glass factory and turned out glass for more than one hundred years until 1767. The earliest furnaces were built on Glass Makers Street, now William Street, center of the insurance business. Later, several furnaces were built farther uptown at the Glasshouse Farm on the banks of the Hudson River. The Jansen and Melyn families were active in these glass-blowing enterprises. Other Dutch artisans who made glass in Nieuw Amsterdam were Johanes Smedes, Cornelia Dirksen, and Everit Duycking, who with his son, Gerrit, made America's first colored art glass for the windows of the Dutch Reformed and other churches in the colony.

In 1739, Caspar Wistar, a German immigrant, sent to Belgium for four glass makers. He set up a small furnace in southern New Jersey and manufactured panes for windows, as well as bottles and glass chemical apparatus. After Caspar's death in 1752, his son Richard enlarged the plant and carried on the work until 1781. Many fine examples of this south Jersey glass survive



Courtesy Corning Glass Works

In 1879, in a glass "shop" like this, Corning blew a bubble for a man named Edison and thus began production of incandescent lamp bulbs, now a mechanized process producing up to 700 bulbs a minute



Why 109 Kinds of Optical Glass?

Bending light to the will of man, making it accomplish miracles, this is the job that optical glass does . . . in industry, science, medicine, and in the service of our armed forces.

Creating the required types of glass, and adapting them to the thousands of precision operations they are to perform, is the task of Bausch & Lomb, America's large scale producer of optical glass and the only company currently producing 109 kinds.

Many of these glasses may look alike, but to the optical expert each is different. That difference is marked by specific qualities of refraction, dispersion, and transmission . . . the properties which determine how light is bent, broken up, and passed through a lens or prism.

Only by having available all of these types of glass . . . and the ability to create new types when needed . . . has Bausch & Lomb been able to meet the optical instrument needs of science and industry in times of peace . . . the needs of our armed forces for highly precise military optical instruments. These combined abilities . . . to create and produce fine optical glass and to utilize its properties to the fullest advantage . . . make Bausch & Lomb America's Optical Headquarters. Bausch & Lomb Optical Co., Rochester 2, New York.

BAUSCH & LOMB

ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry, and Eyesight Correction and Conservation

today in museums and private collections. These authentic examples of early Wistar glass are mostly what is known as "off-hand" blown glass. These are pieces that the workmen fashioned for their friends or families apart from their regular production. To the last run of glass in a pot, they often added a bit of coloring matter and then exerted their greatest skill, out of love for their craft, in blowing useful and ornamental objects.

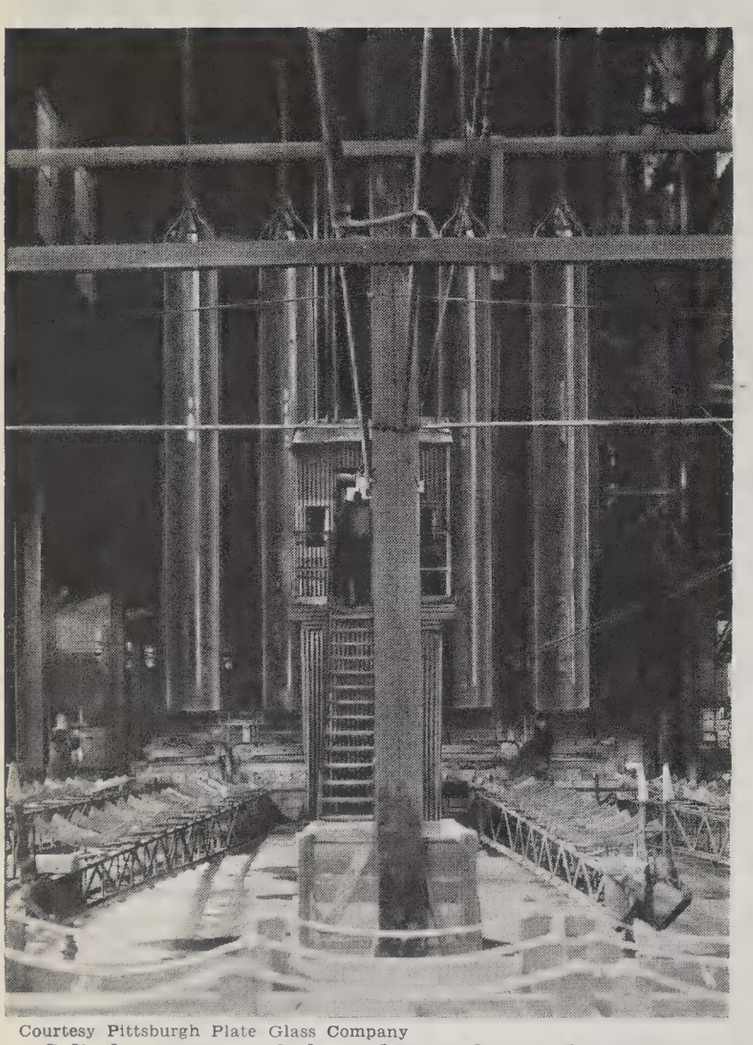
During these years glass furnaces were also established elsewhere in New Jersey and New York. They turned out glassware largely similar to the products of the Wistar manufactory. It was sturdy and substantial, yet graceful and well-balanced.

The most beautiful glass in America was made by William Henry Steigel at Mannheim in Pennsylvania. Steigel, a German, came to America in 1750, and is frequently referred to as "Baron" Steigel, although he was not a nobleman. He was something more important —an energetic and courageous American who made a great artistic and technical contribution to his adopted country.

Believing that there was a need for fine glass in America, he constructed a large glass plant at Mannheim and then went to Europe where he selected and brought back to America from many countries experienced glass workers including cutters, engravers, gilders, and etchers as well as blowers. The first run of glass was made in 1765, and, though everything seemed to point to success, the general depression preceding the Revolution, coupled with Steigel's personal extravagances, caused the enterprise to fail.

In 1784, the struggling glass industry in America received a stimulus to new life when 82 experienced glass workers left Bremen, Germany, and came to America. They set up a glass works at Frederick, Maryland, but the business soon collapsed. The failure of this venture and of Steigel's ambitious glass-making enterprise testifies to the great difficulties that faced the infant glass industry in the newly established United States.

Many of the German glass workers who had lost their jobs when the Maryland attempt ended, found work in glass plants that were springing up in the coastal cities or they crossed the Alleghanies to obtain employment in the glass furnaces being erected in Ohio, western Virginia, and Pennsylvania. On a hillside along the Monongahela River near Pittsburgh, Major Isaac Craig in 1797 came upon an outcropping of coal. This discovery was of great importance to the future of the glass industry because it meant that coal would gradually supplant wood as fuel for the glass furnaces. Craig and James O'Hara constructed an eight-pot window and bottle glasshouse near the coal bank, and thus started the great Pittsburgh glass industry.



Courtesy Pittsburgh Plate Glass Company

Cylinder process of sheet-glass making, ultimate refinement of the old blow-pipe method. The cylinders, here about 30 feet long, are blown by compressed air

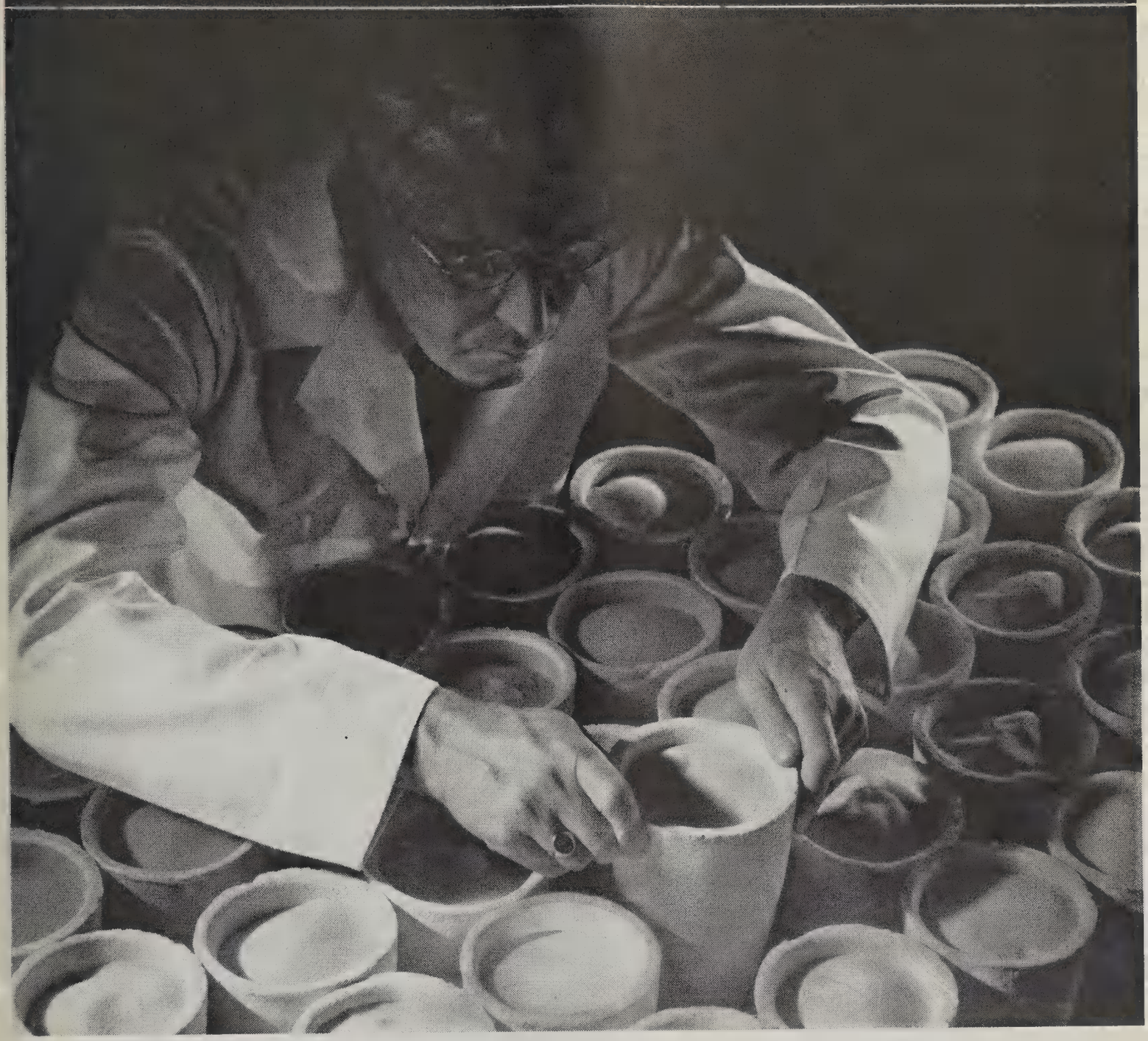
THE 19TH CENTURY—The opening of the 19th Century in the United States, then, found the glass industry small and weak, struggling against great difficulties for survival. There were many reasons for this lack of success. Most important was a dearth of sufficient trained workmen. Another reason was the lack of roads in good enough repair to permit the safe distribution of glass products. There were no railroads in those days and the highways were far from smooth. Strong competition from Europe and heavy domestic taxation on glass articles were additional factors working against the industry.

The 19th Century was characterized in America and Europe by the mechanization of productive techniques, and the glass industry was caught up in the general tide. Throughout the eastern states, glasshouses multiplied, turning out household glass and window panes. Deming Jarves, founder of the Boston and Sandwich Glass Company, set out to solve the secret, hitherto baffling to American glass makers, of compounding red lead or litharge which was necessary in order to manufacture crystal glass or lead flint capable of being cut in the English manner. In 1827, Enoch Robinson invented the first crude pressing machine which was at once improved by Jarves. The invention was perfected by 1838 and pressed glass became popular throughout the country, although it did not become a familiar household commodity until about 1845. By that time America was exporting these machines to all the glass centers of the world. The circle was closing. America, which only recently had been compelled to import its glass craftsmen from Europe, was now returning to the old world an improvement that was to become characteristic of its development—a machine to speed production and reduce costs.

SHEET GLASS—From the earliest days the major use of sheet glass has been in windows, and from the time of the Roman empire down to the beginning of the 19th Century the method of its manufacture remained essentially unchanged. Known as the crown method, it consisted of first blowing a hollow glass sphere with a blowpipe. To this a punty—an iron rod used to manipulate hot glass—was attached opposite the blowpipe which was then removed, leaving an opening in the globular mass. After being heated until it was very soft, the ball was rotated rapidly until centrifugal force caused it to flatten out into a disk. It was then removed from the punty, annealed, and cut into small sheets. At the center of every sheet was the "crown" or "bull's eye." Only small sheets of glass could be fabricated by this strenuous process.

The crown method was entirely replaced in the early

He's planting seed for a new kind of Glass...



ONE day the man in charge of research at Corning called in the man who writes these advertisements.

"I think we're making a mistake in our ads," he said. "In these critical times, we should remind people that glass is a basic raw material and that Corning makes many, many different *glasses* for many different kinds of jobs."

It sounds almost unbelievable, but Corning has developed more than 25,000 glass formulae. Every day chemists pour widely varying raw materials into rough clay crucibles to obtain more types of glass. The results are to the glassmaker what seedlings are to nurserymen. Some are discarded. Some are used. Some are combined to achieve the sought-after formula.

This patient labor has led to such remarkable discoveries as the Pyrex brand heat resisting glasses. It has produced glasses of a hardness that compares with steel. It has produced crystal as clear as dew.

Corning is able to help in the war because its hundreds of research people are backed by over three-quarters of a century of experience in the hands of glassworkers who understand the possibilities of this wonderfully versatile material. Maybe you can turn some of this knowledge and skill to a profit when your peacetime plans reach the blueprint stage. Corning Glass Works, Dept. 59-S, Corning, New York.



CORNING
means
Research in Glass

years of the 19th Century by the hand cylinder technique. This consisted of gathering from the tank enough molten glass on the end of a blowpipe to make a cylinder from 15 to 20 inches in diameter and from 50 to 70 inches long. When the blower had formed a cylinder of fairly uniform surface thickness, the ends were removed and the cylinder split and placed in a heating oven where it was softened and flattened with a wooden tool or hoe. After passing through a lehr (annealing oven), the glass was cooled and cut into required sizes. Great labor and considerable skill was required in making window glass by this slow process.

Up to the end of the 19th Century nearly all window glass was made by the hand cylinder method. Mechanization began when J. H. Lubbers introduced a machine-blowing process. In his machine, molten glass was poured from a ladle into a drawing pot. A circular metal bait about ten inches in diameter, on the end of a blowpipe, was dipped into the surface of the melt. By withdrawing it slowly by means of an electrical hoist and applying carefully controlled compressed air, a continuous cylinder was formed to a height of about 40 feet and approximately 30 inches in diameter. The subsequent work of splitting, flattening, annealing, and cutting were the same as in the hand cylinder method. The production rate, however, was higher because the cylinders were far larger and could be blown with greater speed.

But the great need in the production of window glass was a continuous method of manufacture. The undulations and waves in window glass, the principal causes of distorted vision, could not be eliminated as long as the manufacturing process involved the flattening of glass cylinders. The problem was solved in the United States and abroad almost simultaneously.

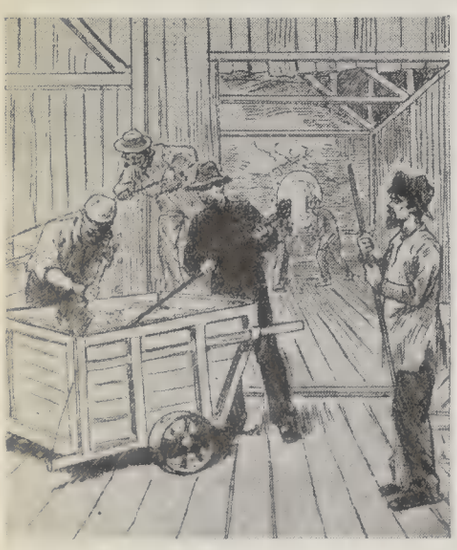
Emile Fourcault invented in Belgium a practicable machine for the continuous production of sheet glass, relatively free from waves. In America, Irving W. Colburn invented a similar machine that was put into use in 1917 in Charleston, West Virginia, by the Toledo Glass Company, later merged with the Libbey-Owens Sheet Glass Company. The Fourcault process was introduced in America in 1923 by the Blackford Window Glass Company. About that time a third continuous process was developed by the Pittsburgh Plate Glass Company.

A GREAT INDUSTRY—The fact that these automatic and continuous methods of manufacturing sheet glass had been developed at the cost of much laborious experiment and the investment of millions of dollars meant that glass manufacturing had grown in the early decades of the 20th Century to be a great American industry. Its emergence as one of the giants of American industrial development was the result of the rapid growth of a number of American glass-making companies lead by energetic and intelligent men. Some account will be given later of the start and growth of the organization that is now the Pittsburgh Plate Glass Company. There were others of equal importance in the rise of American flat glass manufacturing. Outstanding among these is the Libbey-Owens-Ford Company of Toledo, Ohio. The three men whose names are perpetuated in the company name were leaders, each in a different way, in the development of the American glass industry. Edward Drummond Libbey was a New Englander who moved his small glassworks from East Cambridge, Massachusetts, to Toledo in 1888. He was one of the most skilful and artistic producers of cut glass and his work was extremely popular during the nineties when cut glass was greatly in demand.

Son of a West Virginia miner, Michael J. Owens was a glass blower and labor representative in the Libbey factory. He later became superintendent and invented the Owens bottle machine in 1899. The third man who contributed greatly to the development of the present company was Edward Ford, son of Captain John B. Ford, America's pioneer plate-glass manufacturer. Edward Ford retired as president of an eastern glass works in 1896 and resolved to establish a glass works of his own. He saw in Toledo an ideal location for a glass factory, and he purchased 173 acres on the Maumee River where he established the model town of Rossford for his employees and constructed what was then the largest plate-glass plant under one roof in America. It had a capacity of six million square feet a year. This output was later doubled and is now many times greater. These three pioneering leaders of the glass industry died between 1920 and 1925 and their companies were merged in 1930.

PLATE GLASS—The same difficulties that made the beginnings of the sheet and household glass industry in America hesitant and precarious also attended early ventures in the manufacture of plate glass. In 1850, an attempt was made to establish American manufacture of plate glass on a stable and successful basis. A company was formed, certain European patents obtained, and a factory was built at Cheshire, Massachusetts. The business was later moved to Brooklyn where it faltered and died in 1856.

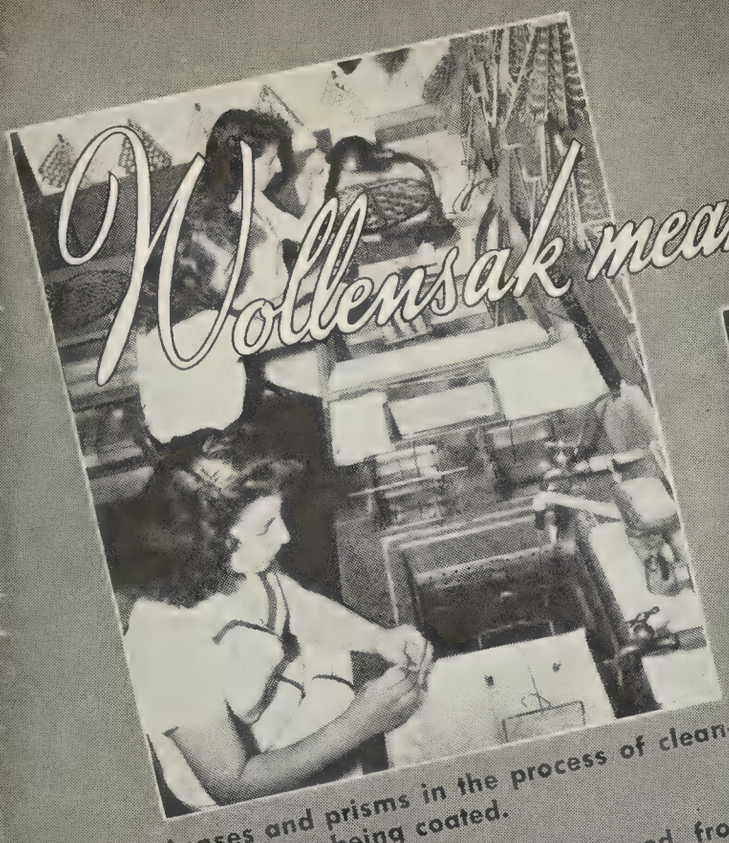
Another group founded a plate-glass factory at Lenox, Massachusetts, importing for the purpose the best foreign equipment and utilizing the most advanced European techniques. Excellent plate glass was produced, equal to the best imported from Europe. Nevertheless, this company failed in 1871. Failure was also the lot of a plate-glass enterprise started in New Albany,





Left: Mixing a batch of glass ingredients in an old-time glasshouse. Right: In a modern Bausch and Lomb optical glass plant, the batch is accurately weighed

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LENS COATING means EVEN FINER Wollensak Lenses . . .

A major wartime achievement in the field of optical glass, *lens coating* will increase the light-transmission quality of many postwar Wollensak lenses.

When you see the guarantee, "This instrument has COATED OPTICS," on your new Wollensak Photo Lens Prism Binocular, Rambler Field Glass, or Vari-Power Scope, you'll know your lens will give sharper, more brilliant images . . . help you get more fun from sporting events, hunting trips, vacation travels.

After the war Wollensak instruments will again be available for sports lovers . . . offering many new, improved features achieved by Wollensak skill and experience in precision manufacture.

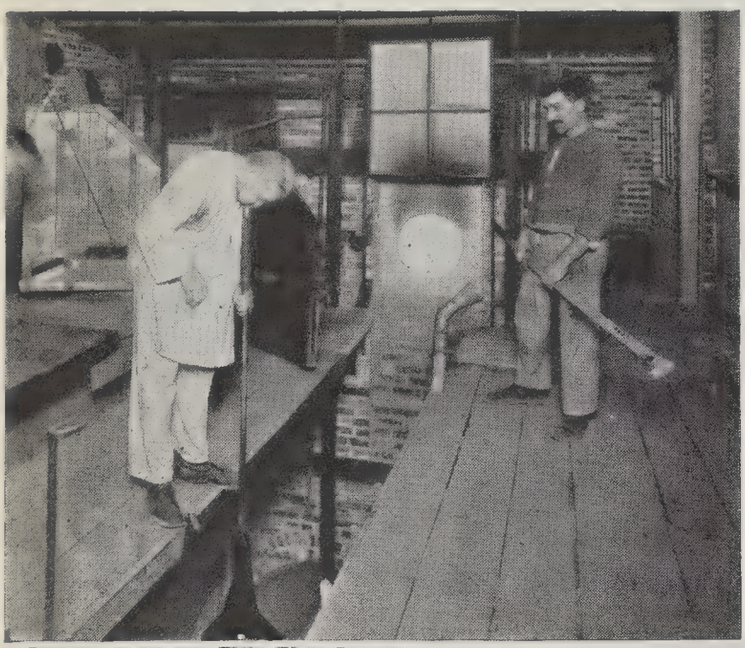
Wollensak ROCHESTER 5, N. Y., U. S. A.

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Indiana, by Captain Ford. But Ford, who had made an intensive study of glass making in America and abroad, was convinced that plate-glass making in America had a future. With others, he formed the New York City Plate Glass Company, and in 1880 constructed a factory in Creighton, Pennsylvania. This enterprise later became the Pittsburgh Plate Glass Company and the factory at Creighton is now known as Works Number One of that corporation.

Realizing that the success of the company depended upon attaining economy of operations through mass production, its directors energetically commenced the development of machinery for large-scale manufacture. This development in turn led to a tendency to reconstruct the entire glass-making method itself. Until this time, American plate-glass makers had followed European processes and had used European machinery either ready built or made from foreign specifications.

One of the first problems tackled by the Pittsburgh company soon after 1895 was the development of a continuous process for the manufacture of plate glass. The method then in use consisted of melting the raw materials in pot furnaces, pouring the molten glass on water cooled tables made of cast iron, and hand rolling it flat. After these operations, the sheets of glass were manually transferred to fixed lehrs and later transferred again by hand to the fixed grinding and polishing lathes. This



Courtesy Pittsburgh Plate Glass Company

Forming a glass cylinder by lung power, the only method used up to the end of the 19th Century. The helper at the right assisted in handling the cylinder

method was time-consuming. Much labor and time was expended in the work of moving the glass from pot to rolling table, then to lehr, and later to grinding table.

The first step in improving this lengthy process was the invention of a rod lehr to replace the fixed annealing lehr, and in a short time this in turn was superseded by a continuous roller lehr which cut annealing time from a matter of days to hours.

There still remained, however, the laborious and time-consuming job of carrying the sheets of glass from the lehr to the grinding table and later to the polishing table. The solution was found in the installation of conveyor lines. A moving belt of metal table tops was arranged to convey the glass under rotating, grinding, and polishing disks, thus making it possible to grind and polish the glass in a continuous manner. During the years between 1900 and 1920, the continuous conveyor system for both lehrs and finishing processes was constantly improved. This was achieved by further mechanization of the intermediate transfer steps, increases in the size of pots, enlargement of the capacities of lehrs, as well as improvements in grinding and polishing abrasives and in the manner of pouring the melt from the pots.

One gap remained, however, to prevent a continuous mechanical production line from raw material to finished product. This occurred at the point where the molten glass was poured from the pots to the iron tables to be rolled into sheets. In 1921, this gap was bridged. Now plate glass is melted in large continuous tanks and flows from the refining end through a gate over a wide spout in a continuous stream, passing downward along an inclined plane between two water-cooled rollers. It



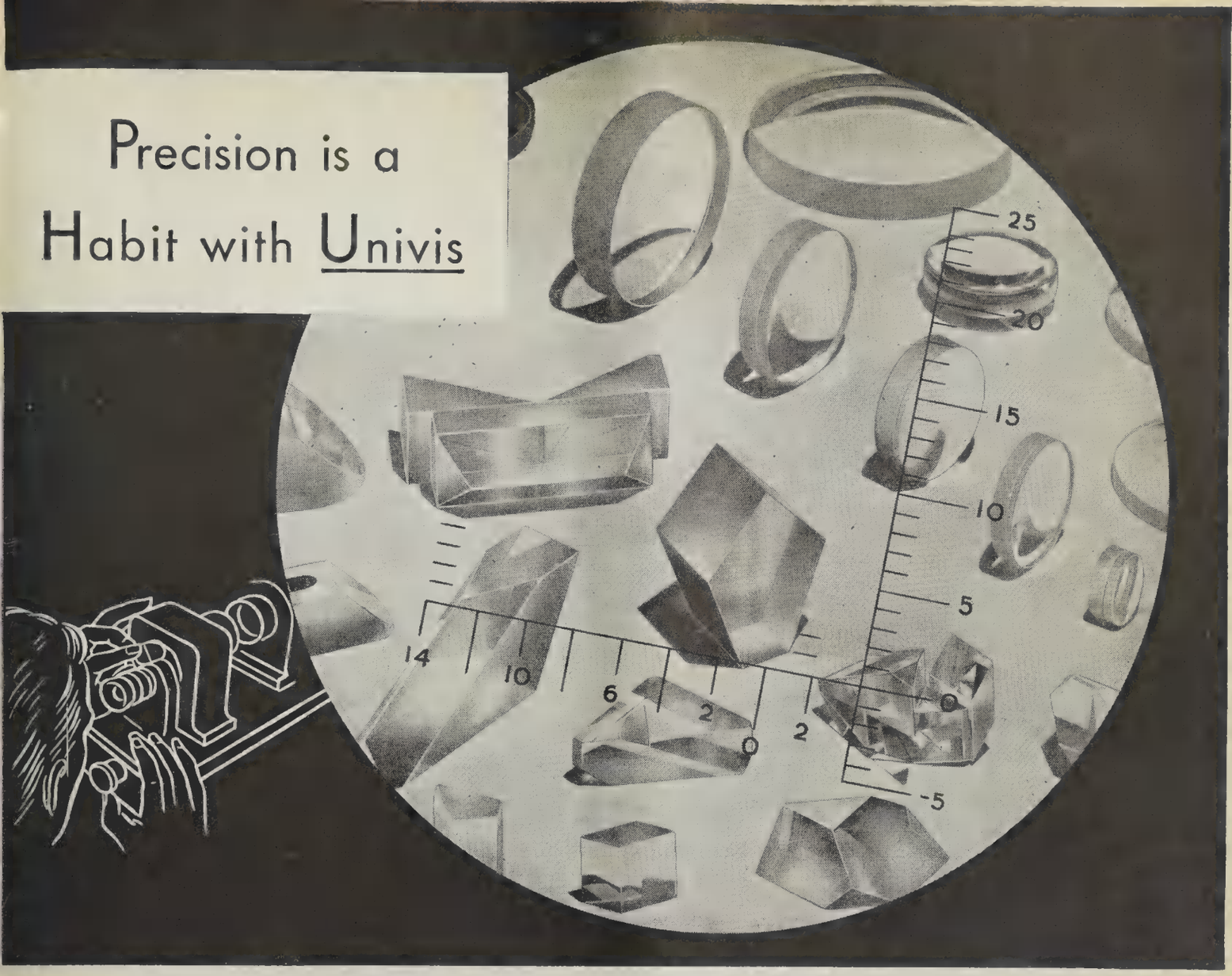
Plate glass polishing in the 1800's. Weighted felt buffers were used and the whole surface of the glass was covered with rouge and water. The table reciprocated

emerges as a flat ribbon of uniform thickness and width and is pulled by multiple rollers through the lehr. It is then cut and inspected before passing into continuous grinding and polishing machines.

Continuous mass-production methods of manufacturing plate glass permit an enormous output to meet the demands of the modern world for clear, strong, transparent glass. Plate glass, once a rarity, is now used everywhere. Prior to 1889, about ten days were required to make a piece of plate glass from raw materials. The time has now been reduced to 22 hours after the raw materials enter the glass-making plant. The greatest size of the sheets is about 127 inches by 286 inches, while the range of thickness runs from ⅛ inch for automobile glass to 1¼ inches for the heaviest plate glass.

CONTAINER GLASS—During the years of growth of the sheet- and plate-glass industry in the United States, the manufacture of glass containers was also growing by leaps and bounds. The power behind this growth was the mechanization of the glass blowing process. In 1838 a four-ounce cologne bottle made in a glass factory for the Reeves Drug Store in Boston was first blown in a clay mold and then stuck up on a punty, the shoulder, neck, and finish being shaped by the blower with a pair of shears, the bottle being reheated several times at the furnace while this was being done. A day's work for the blower was 216 bottles and his working day lasted 12 or 14 hours. Today glass blowers turn out as many

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bottles in about three minutes, using modern methods.

Mechanization of bottle making received great impetus in 1882 when Philip Arboblast of Pittsburgh invented the first press and blow machine. His conception was later improved in the Teeple-Johnson machine which employed two turrets each carrying three molds. Still later developments lead to fully automatic press and blow machines of all kinds. A typical machine now in use has 12 blank and 12 blow molds all on one table which is operated mechanically. Compressed air actuates a plunger and a vertical camshaft operates timing valves.

Another of the early steps toward complete mechanization of bottle making was the suction or vacuum gathering device invented in 1899 by Owens. This was first installed on a machine having six arms, each equipped with a mold which, when placed over the rim of a revolving pot of glass, obtained its charge by suction. The gather was cut off by a shear sliding across the lower end of the mold. Individual dip machines with ten sections were later developed. In these, instead of having the whole machine raise and lower itself each time a mold was dipped into the pot, the individual blank mold was lowered as it passed over the pot, much as a horse dips its nose into a watering trough. Although many improved models of the Owens machine have been brought out in recent years, the fundamental principle remains unchanged: a fixed amount of molten glass is gathered by suction. This kind of machine is used to produce about 30 percent of the glass containers made in this country and it has been adapted to manufacturing bulbs and tumblers. A later development was the "gob" feeding device of Peiler, an improvement on the Brooke flowing device invented in 1903. It delivers a large charge of molten glass of predetermined weight, size, and temperature.

In the manufacture of glass specialties, such as tumblers, bowls, and tableware, mechanization, starting with the old side-lever press, proceeded rapidly until today fully automatic machines are used in conjunction with a continuous melting tank, a mechanical feeding device, and an automatic "take-out" for removing the ware.

Another contribution to the increased productivity



Courtesy Corning Glass Works

At left, the "gaffer" (finisher) has blown a bubble of molten glass and is shaping it preparatory to the final blowing operation in the mold, as in picture at right



Courtesy Bausch and Lomb Optical Company

Making pots for optical glass by the old hand method. A newer method involves casting pot material in mold

of glass manufacturing was the development of the paste-mold blowing machine which can turn out as many as 120 40-watt bulbs or 40 tumblers a minute. But the last word in automatic glass working machinery is achieved by the remarkable ribbon machine developed by the Corning Glass Works, primarily for the manufacture of electric light bulbs. Speeds of 400 to 600 bulbs per minute are common and production has been raised at times to 700 per minute.

The Corning Glass Works had its beginning in Summerfield, Massachusetts, in 1851, operated in Brooklyn, New York, for a few years in the early 1860's, and moved to Corning, New York, in 1868. One of its earliest advertising signboards modestly proclaimed that it manufactured "plain pressed and moulded glass-ware of every description." By 1879 the Corning plant was producing thermometer tubing, laboratory supplies, and railroad signal glass. That it had an important hand in early research and experimental work is evidenced by the fact that in 1879 a glass bubble was blown for Thomas A. Edison, starting the production of incandescent lamp bulbs which culminated in the automatic machinery described above.

From Corning has also issued much of the heat-resisting glassware so important in industrial and laboratory processes, and equally valuable to the modern housewife in the form of glass cooking utensils. Their research facilities have contributed largely to the production of other glass specialties such as toughened glass, glass fiber, and so on. In 1934 Corning successfully tackled the largest single job in the history of glass-making—the casting of the 200-inch refractor for the giant telescope which, post-war, will make Mt. Palomar the Mecca of astronomers.

OPTICAL GLASS—While the sheet-, plate-, and container-glass industries were growing into maturity in the latter part of the 19th and early part of the 20th Centuries, another important branch of glass technology was struggling to get started in America. This was the manufacture of optical glass.

Eight years before the thunder of the cannon at Fort Sumter announced the beginning of the bloodiest war in young America's history, two German lads who had left their native land to find greater freedom and prosperity in the new world, decided to go into the business of manufacturing eyeglasses in Rochester, New York. They



How many of these do you own?

If you look under your car, you'll probably find a couple of gadgets something like this one.

They're shock absorbers.

They take the sting out of sudden bumps and jolts. They make a rough road smoother.

And if you're wise, somewhere in your desk, or bureau drawer, or safe deposit box, you have a lot *more* shock absorbers. Paper ones. War Bonds.

If, in the days to come, bad luck strikes at you through illness, accident, or loss of job, your War Bonds can soften the blow.

If there are some financial rough spots in the road ahead, your War Bonds can help smooth them out for you.

Buy all the War Bonds you can. Hang on to them. Because it's such good sense, and because there's a bitter, bloody, deadly war still on.

BUY ALL THE BONDS YOU CAN...
KEEP ALL THE BONDS YOU BUY

SCIENTIFIC AMERICAN

This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council

were John J. Bausch, a trained optical worker, and Henry Lomb, an ambitious young cabinet maker. The business grew rapidly even though Henry Lomb took time off to fight in the Civil War where his bravery and intelligence caused him to rise from the rank of private to captain. By 1875, the demands of the business required the construction of a three-story factory building, and in the same year Bausch's three sons, Edward, William, and Henry, entered the firm. Of these, Edward was most active in developing the manufacturing of optical instruments, and at his death in 1944, after 69 years of service to his company, was regarded as one of the foremost authorities on microscopes in America. One of his outstanding achievements was the pioneering in the application of mass-production techniques in the manufacture of precision optical instruments.

In this he had great success, and his success meant a healthier, more prosperous, and more enlightened America. A measure of his contribution can be found in the fact that six years before Bausch and Lomb began the manufacture of microscopes, in 1870, there were only 50 in the United States; sixty-five years later Edward Bausch presented to the University of Michigan the 250,000th microscope made by Bausch and Lomb. When this company made its first microscopes, a good one cost about $1000. Within a few years, Bausch and Lomb were making a superior instrument that sold for less than $200.

The outstanding achievement of William Bausch was his work in teaching America how to manufacture optical glass. Until the outbreak of World War I, virtually all the optical glass used in America was imported from Europe where the exacting techniques of its manufacture were closely guarded secrets. The attempt of Charles Feil, great-grandson of Pierre-Louis Guinand, to manufacture optical glass in America had fizzled out at the turn of the century and had not been tried by others.

As early as 1912, William Bausch realized how important it was to make optical glass in America in the event that a European war cut off importations, which by that time had swelled to considerable volume. He devoted nearly all his time to the problem of manufacturing high quality optical glass. Laboring with a few enthusiastic assistants William Bausch pushed the work forward despite difficulties and discouragements. Great progress was achieved, however, and by the end of 1916 he and his co-workers produced the first large quantity of optical glass made in America. It was used in several hundred high-priced anastigmatic photographic lenses of a type previously made only from the best imported glass.

The United States Bureau of Standards, the Pittsburgh Plate Glass Company, as well as a number of other glass makers, had produced small experimental quantities of optical glass prior to World War I. When that event occurred, American production of large quantities of optical glass became imperative. It was needed for artillery range finders and many other military purposes. The government mobilized the best glass-making brains in the country, as well as authorities on the properties of light, and sent them to Rochester where, in collaboration with Bausch and Lomb, production of optical glass was enormously increased. By the end of the war, Bausch and Lomb had produced 450,000 of the total of 650,000 pounds of optical glass made for military purposes.

SPECTACLES, PLUS—Back in 1831, William Beecher, a jeweler decided to go into the business of manufacturing spectacles in the little town of Southbridge, Massachusetts. From this modest beginning grew an industry that was to make this small town into one of the great optical centers of the world. For 30 years Beecher's business grew slowly, reaching an important milestone in progress when, in 1864, George W. Wells joined with him as an apprentice. By 1869, through the initiative and vision of Wells, the business was incorporated under the name of American Optical Company. To the work of the company Wells applied modern production methods and changed the manufacture of spectacles from a slow hand operation to what is today a speedy machine process.

In 1891, three sons of George W. Wells—Channing, Albert, and Cheney—entered the service of American Optical Company and ably forwarded its activities until they now span the entire nation and its products include not only eyeglasses but innumerable types of precision optical instruments. It may seem odd that this important company in the optical field makes no glass on a commercial scale. Yet its influence on optical glass practice has been enormous. From its research laboratories have come a broad range of improvements and developments in glass technology and applications. Today all the glass used by American Optical Company is made to its specifications by Pittsburgh Plate Glass Company.

Side by side with American Optical, in point of time, grew the Spencer Lens Company, which had its genesis in the work of Charles A. Spencer who, about 1838,



A hand truck of the vintage of 1917, used for handling optical glass pots, required services of seven men



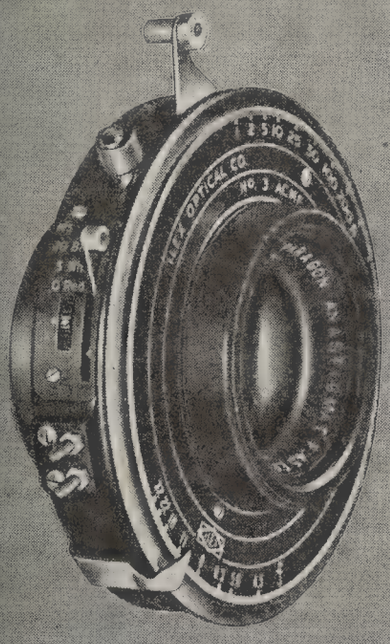
Courtesy Bausch and Lomb Optical Company

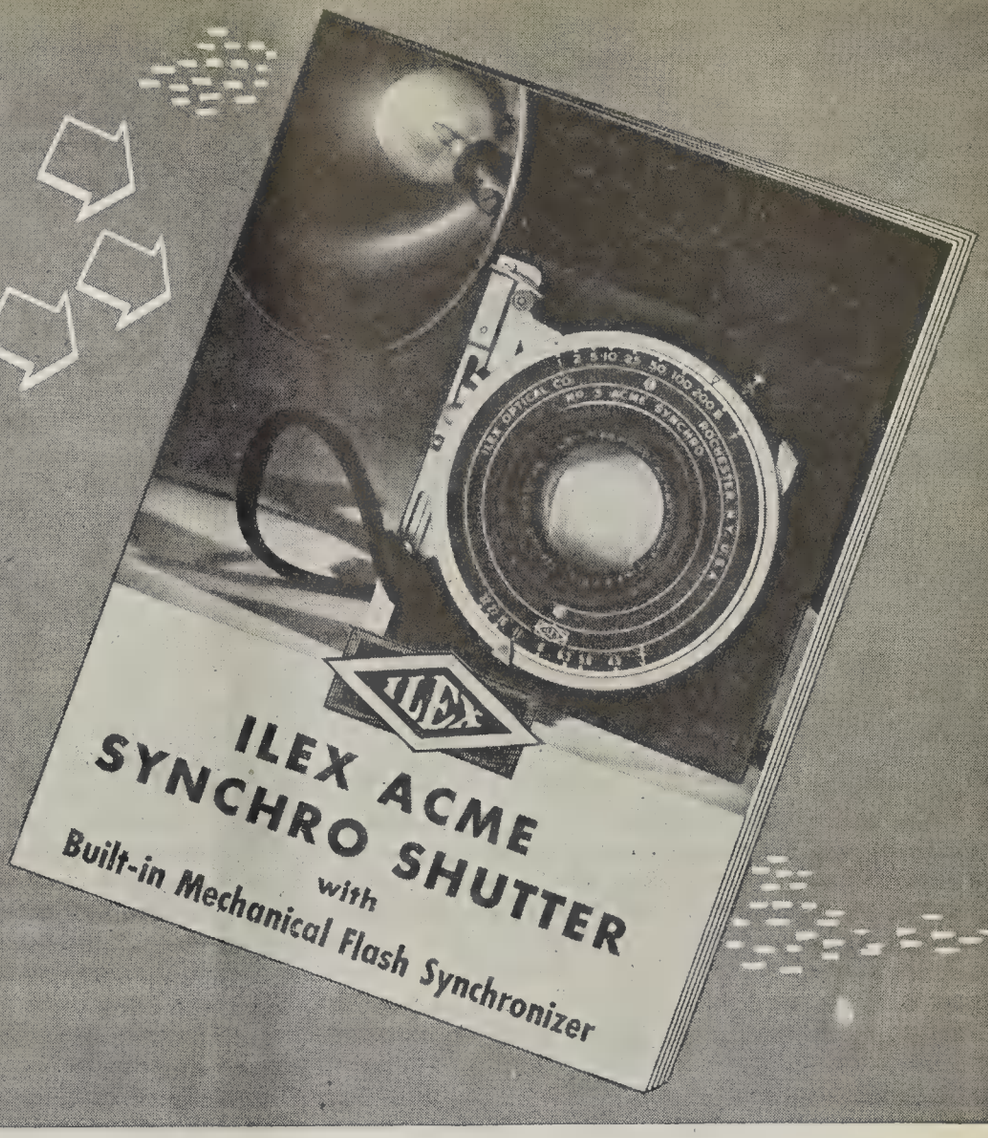
A modern pot-handling truck rolls on pneumatic tires, is completely mechanized, and is operated by one man

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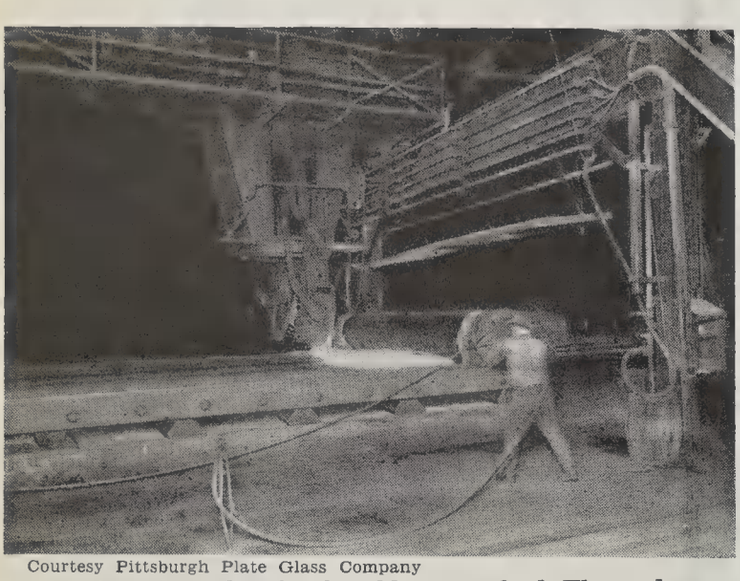
ILEX OPTICAL COMPANY, DEPT. 54, ROCHESTER 5, N. Y.

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SHUTTERS AND LENSES — ILEX — OPTICAL INSTRUMENTS

set out as a manufacturer of telescopes and microscopes. For many years, with the assistance of Robert B. Tolles and later of his son, Herbert R. Spencer, he pioneered in the design and manufacture of fine microscopes and microscope objectives, bringing to America a leadership in this branch of science in which glass plays so great a part.

Spencer Lens is linked here with American Optical Company because, in 1935, the Spencer organization was added to American Optical in order to round out the line of ophthalmic and optical products, and, in 1945, became known as the Scientific Instrument Division of the American Optical Company.



Courtesy Pittsburgh Plate Glass Company

Casting plate glass by the old pot method. The molten glass was conveyed by a crane from the furnace, dumped on the metal table top, and flattened. Modern plate is manufactured in one continuous operation

GLASS TODAY—The years immediately preceding World War II saw the uses of glass proliferating at an astonishing rate, spreading into every phase of American life. Factory and office buildings, homes, schools, theaters, and stores were erected in which glass in some form or another took the place of opaque walls of masonry. Glass block was used in walls and partitions and colored glass in facades, windows were of double glass and plate glass, while tempered glass doors and skylights and partitions of fire-resistant wire glass all came to be more and more widely employed. The use of great expanses of plate glass in shops and other retail outlets revolutionized the art of merchandise display and store design during the decade of the 1930's. Shatter-proof glass came into wide use in modern automotive vehicles, reducing the danger of serious injuries from flying glass in accidents. In the home, heat-proof glass cooking utensils added a new dimension to comfortable living.

In electricity, also, glass has found many uses. Because it is a homogeneous, non-porous material, smooth, hard, and highly resistant to weathering and other kinds of chemical attack, and at the same time possessing high electrical resistivity, it has found wide application in high-tension insulators. Then there is that staple of modern civilization, the incandescent lamp. Millions upon millions of them are in use, all made of glass. One company alone, the Corning Glass Works, manufactures at least 880 different sizes and shapes of bulbs. The growing popularity of fluorescent lamps and neon tube lighting has caused an increase in the manufacture of glass tubing, specially designed for this kind of illumination. In medicine and industrial research the uses of glass apparatus are virtually limitless. Much of this glass equipment is individually designed and manufactured for specific tasks.

Fiberglas, as manufactured by the Owens-Corning Fiberglas Corporation, is a form of glass that can be bent like rubber, twisted like thread, squeezed like a sponge. It has high temperature resistance and also resists the corrosive effects of acids. It is finding wide use in industry as an insulating material while in medicine it is speeding the treatment of dangerous burns and other injuries.

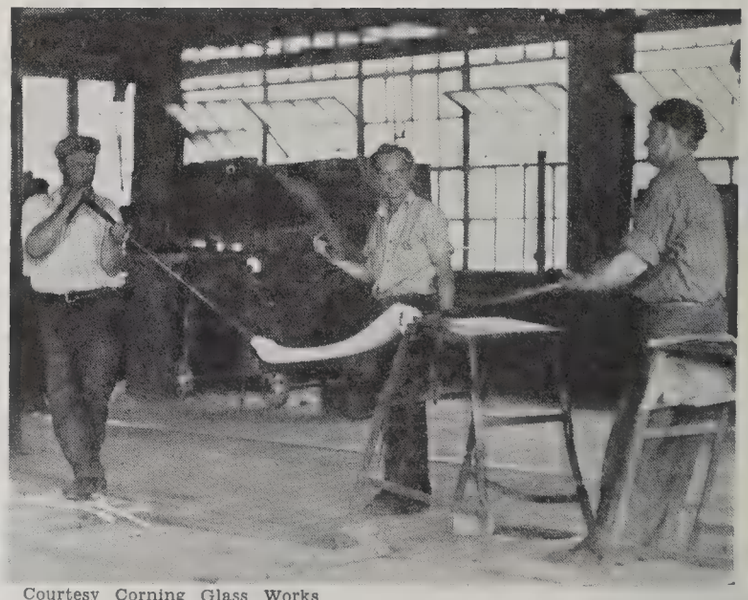
Another development of recent years, Polaroid glass, a product of the Polaroid Corporation, has found application in many forms to protect human eyes from the harmful effects of glare.

THE WAR AND AFTER—America's entry into World War II expanded enormously the demand for optical glass and glass for scientific and medical purposes. Shortage of metals for food containers caused food packers to turn to glass for packaging their greatly increased output of prepared foods. A nation hell-bent on victory gardening and home canning demanded glass containers. The industry met the test.

War-time production of optical glass at the Bausch and Lomb plant shot up to 1200 percent of the pre-war level. Since Pearl Harbor, five million pounds of optical glass has been made there, consuming upwards of 31 million pounds of sand and other raw materials. From this glass has been produced over 100 million pressings for optical elements. They have gone into an immense variety of instruments used in the armed forces of the United States and her allies.

The flat-glass section of the industry has been turning out bullet-resisting glass for tanks and planes. The manufacturers of all kinds of glass containers produced far more bottles and jars than they ever had thought possible. Glass containers were put to an increasing variety of new uses, and many of these uses will stick even when materials now scarce are available once again.

When the war finally ends, the glass industry will stand at the beginning of a period of unlimited expansion. In the 20th Century the difficult problem of glass production on a large scale has been overcome, and in the future, glass, in many new and more durable forms, will come into its own. America is on the threshold of an age of brightness, an age of cleanliness, an age of glass.



Courtesy Corning Glass Works

Drawing glass tubing by hand, a method still in use for certain drawing jobs. The man in the center "fans" the glass to cool and prevent it from sagging

Cutting Oil Comes Back

Plain Water, Water-and-Oil Mixtures, and Straight Oils All Have Helped to Speed Machining Processes and Make Them More Accurate. Every Time Tool Materials Changes Seemed to Point to the Possibility of Eliminating Cutting Oils from the Machine, It Was Found that Better Work Could be Accomplished by Keeping Them on the Job

One of the fondest hopes of many machine-tool designers and tool-materials metallurgists has been to get rid of any need for cutting oil, or at least to reduce it to the ranks as a mere "coolant."

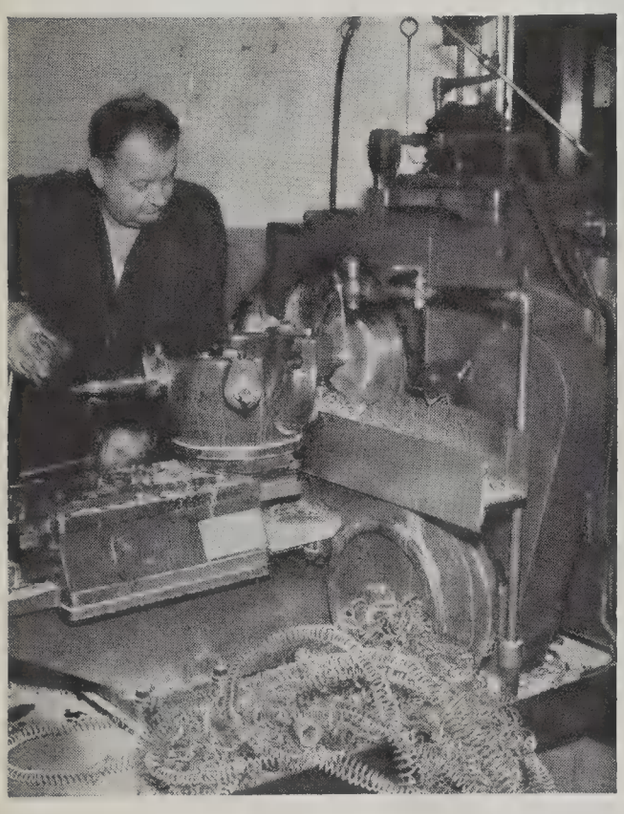
No machinist ever has genuinely wanted the stuff on his machine. Back in 1880 when Taylor (the father of methods engineering) cooled the carbon-steel tools on a lathe by flowing a stream of cold water on them, his idea was called a "stunt" and a "threat to the ancient art of machining." The trouble with the objections was that Taylor managed to increase machining speeds by 80 percent when he cooled his tools. And, of course, no manufacturer could run machines at any slower speeds than Taylor did and remain in competition.

High-speed tool steels came along in the early 1900's. Here were tools that would stand much higher cutting temperatures than the old carbon steels. In fact, the high-speed alloys were inferior to carbon steels unless the cutting speeds and stresses were high enough to generate working temperatures above those which carbon steels would stand.

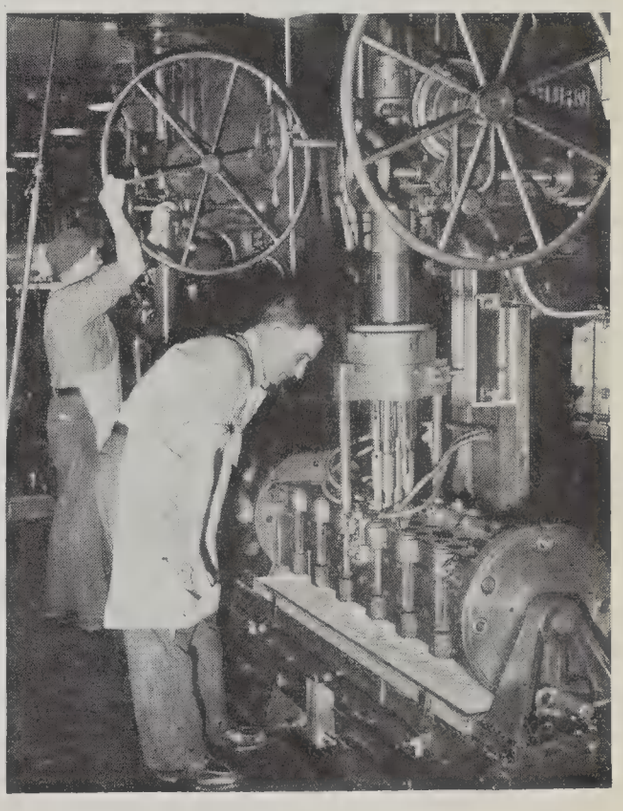
Quite a few tool engineers read coolants out of the picture right then and there, but their hopes were short lived. High-speed steels would do plenty without coolants, but would do ten times more with them.

In the meantime, tool engineers had been experimenting with coolants. They mixed soda with the original plain water and cut down the rust problem which the water had brought to the machines and the finished work. They tried lard oil and found that any oil which contains fat, whether made from animals, vegetables, or synthetically from coal or petroleum, would do wonders in helping the tools to cut sharper threads, more intricate forms, and smoother surfaces in general. Nobody knew why the fatty oils had this quality for making machining more accurate, and, strange to say, nobody yet knows. But the fatty oils enabled machines to do better work at higher speeds, and they stayed in the machines.

During World War I the cobalt alloys for cutting tools came into common use. Here were tools which did their best work when red hot. In fact, their one fault was that they were too brittle until they reached red-hot temperatures. And when, in the 1920's, the tungsten and the



Cutting oils of all-around types work with nearly any tool and increase the versatility of the versatile turret lathe



A flood of emulsion forces out chips, improves finish, holds accuracy high, and increases the work speed

tantalum carbides (which would work when either cold or red hot) came in, cutting oils seemed to be on their way down if not out.

CHATTER-FREE — Machine-tool makers again got ready for a brand new era. They made their machines stiffer because the carbide tools will break if heavy cutting loads cause the vibration known as chatter. They sought out the causes of chatter, found that it always vibrates in the sonic frequency of some part of the tool mounting or of the machine. They used stiffer metals here, higher accuracies there, ribs and reinforcements in other places. But strengthen as they would they still found that machine tools could be chatter-free at higher speeds and on tougher jobs only if they used cutting oils. So thoroughly was this learned that the Carboloy Company (makers of tungsten carbide tool tips) has issued some of the most informative and intelligent data on how to feed cutting oils to the points of work.

Cutting oil was still proving its case, all right. But the users of carbide tools seemed to need only water mixtures of it, with the mixture often containing only one part of oil to 20 or even 80 parts of water; 100 to one mixtures were not unknown. As had been the case with Taylor away back in 1880, it was the water which did nearly all of the cooling. Oil and a few chemicals were in the mixture mostly as rust preventives; a thin film of the oil would cling to the finished work pieces and prevent them from corroding while in storage waiting for the next operations on them, and this same oil would protect the machine.

Grinding increased in use as a secondary operation also. A high proportion of finished steel pieces had to be heat treated to increase their hardness and toughness. It seemed easiest to machine them to quite accurate and fairly rough surfaces, then harden them, and later grind them to remove not only the roughness left by the machining but also to correct any roughness and distortion imparted by the heat treatment. Grinding machines seemed to get along very well with coolant mixtures which started at 40 parts of water to one of oil for the heaviest work and were made thinner as the grinding cuts became lighter.

NEW FACTOR—All of this seemed to mean that cutting oils were becoming mere coolants which could be bought on price and dismissed with a wave of a splash guard as serious factors in the world of machine-tool operations. But a new factor was coming into the picture. Machine-tool users wanted to machine harder and harder metals, at higher and higher speeds, and with greater and greater accuracies.

They soon were taxing the new found strengths and power capacities of their machines to the utmost limits. And then the cutting oils began to repeat their oft told story. Far tougher alloys could be machined with them than without them, and at far higher speeds.

Machinists found that they could cut steels so hard and tough that for many purposes no further hardening was needed. But they still had to have their high accuracies. They began using more of "straight" cutting oils (straight cutting oils are not mixed with water) and getting their accuracies. By 1940 many a finished piece was being made more accurate in dimensions and with smoother surfaces on a lathe or an automatic screw machine than had been produced by hardening and grinding only a few years ago.

This did not put the hardening furnaces and the grinding machines out of work. The steel heat-treaters quickly pointed out that the distortion in hardening, and many another hardening trouble, could be reduced if the original machining was more accurate. They began the modern methods of "predicted distortion" by which a piece that is machined very accurately to one set of dimensions can be so hardened and toughened that it will come out of the quenching tanks just as accurate but to slightly changed dimensions.

The grinders in turn showed that with more accurate original machining and more accurate hardening of extremely hard and tough steels the grinding operations could be made to produce accuracies which were undreamed-of a few years ago. After all, no outright metal cutting operation ever can attain the accuracies of grinding, lapping, and honing. And, in addition, the grinders could grind more intricate shapes than had been previously considered practical, and could grind them at very high speeds.

It was this combination of extremely hard and tough metals, machined to high accuracies, hardened to just as accurate dimensions and then ground to exquisite accuracies, which brought the modern airplane, automobile, television transmitter, and machine tool into being. Strength comes from toughness and hardness of material, but it is greatly promoted by accuracies of dimensions and finishes. Increase the accuracies and the sizes and weights can be reduced. Light weight, so badly needed by some devices, comes largely from increasing the strengths and thereby decreasing the necessary sizes of their parts.

In studying ways and means for making their processes more useful the grinders found that they, too, needed better cutting oils.

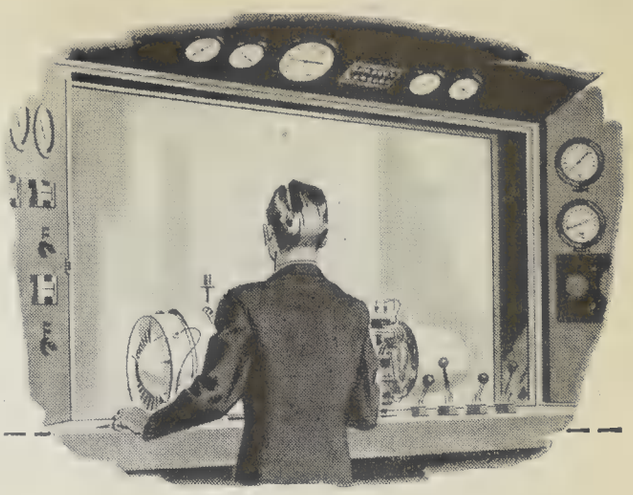
CONSTANT TEMPERATURE—The original water mixes of cutting oils for grinding had been based upon the belief that water, having more heat conductivity than oil, would keep the work cooler, and cooling is

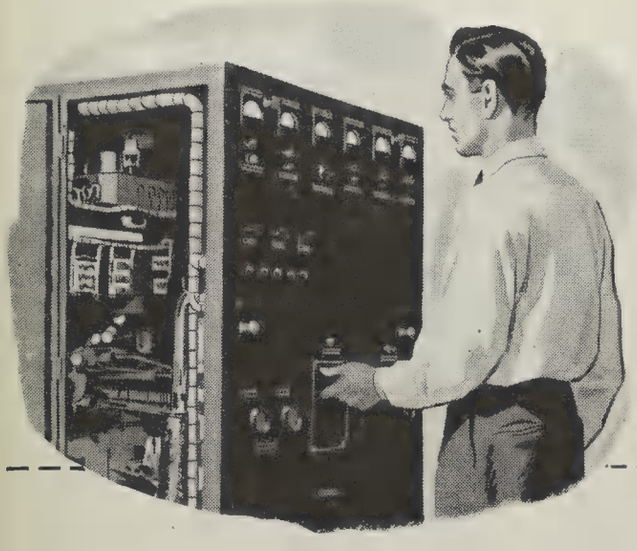


Courtesy Gisholt Machine Company
Cutting oil keeps work cool for accuracy, tool cool and lubricated for long life

In a test cell an ENGINEER studies the performance of a jet-propulsion engine that is expected to produce greater thrust—*for its weight*—than any made in America.

. . . the name on the J-P ENGINE is Westinghouse.



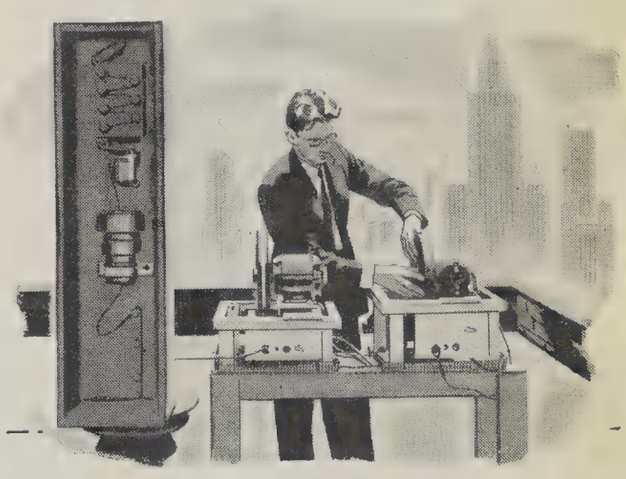


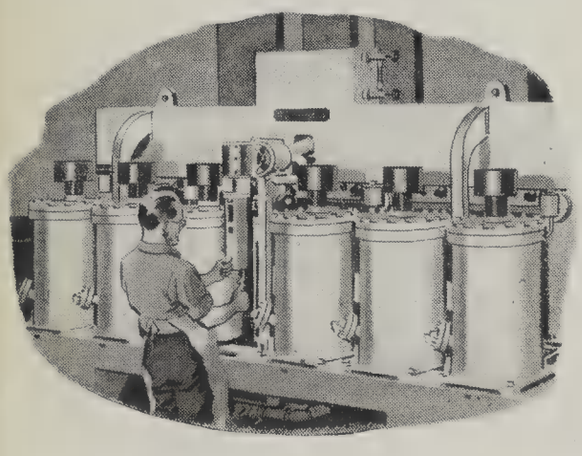
In a synthetic rubber plant a CHEMIST uses a mass spectrometer to analyze a complex gas mixture by sorting its molecules—reducing analyzing time from *days* to a matter of *minutes.*

. . . the name on the MASS SPECTROMETER is Westinghouse.

High in the air a SCIENTIST adjusts a fulchronograph which accurately records the *intensity* and *duration* of thunderbolts—in the never ending study of improved protection against lightning.

the name on the FULCHRONOGRAPH is Westinghouse.





In a refining plant a METALLURGIST uses an Ignitron* rectifier for the more efficient conversion of alternating to direct current—in producing vast quantities of aluminum for our war effort.

. . . the name on the IGNITRON RECTIFIER is Westinghouse.

*Reg. U. S. Pat. Off.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY — Westinghouse war products are making vital contributions to final Victory over our enemies in the Far East.

TOMORROW— Peacetime products . . . backed by Westinghouse research, engineering and precision manufacture . . . will contribute to greater efficiency in industry and better living in our homes.

Tune in: JOHN CHARLES THOMAS — Sunday 2:30 pm, EWT, NBC • TED MALONE — Monday through Friday, 11:45 am, EWT, Blue Network

important. If the work gradually increases its temperature as it is ground, then it also will increase its dimensions, with the result that when it cools again some parts will have had more metal removed from them than others and the work will be inaccurate. Grinding machines have means to compensate for this, but in spite of the best devices the most accurate grinding at the highest production speeds can be done only when the coolant is effective enough to keep the work close to constant temperature.

Superior as the water mixes might be as coolants, the straight oils also had an advantage. Their superior lubricities (abilities to lubricate) cut down the friction between the grinding grits and the chips and the metal right at the points of work. And it is more important to prevent heat than to remove it, since some of the generated heat is sure to go into the work pieces and change their dimensions.

Straight cutting oils soon took over much of the thread grinding and extremely accurate form grinding, and their use on less intricate shape grinding is being increased because fewer "grinding cracks" are produced with them. Grinding cracks are fine fractures on the surfaces of finished work. They are so tiny that a magnifying glass may fail to pick them out, but the magnaflux test will find them, and they result in rejections of parts since they can cause those parts to fail in service.

While extra tough, extra accurate materials-machining was bringing back the cutting oils, plenty was happening in other and closely allied fields.

It has long been known that at highest cutting speeds steel chips will actually weld themselves to tool steels. There is plenty of reason why they should. The temperatures at the heavy pressure areas of the chips on the tools can go well over 1000 degrees, Fahrenheit, with the pressures at those points in excess of 400,000 pounds per square inch.

ANTI-WELDANTS — Nobody can prove that any oil does any actual lubricating at those pressures and temperatures. But the cutting-oil makers put such anti-weldants as sulfur and chlorine products into their oils and stopped the welding. They found out that much of the welding had been invisible and undetected, that tiny bits of the chips had welded themselves to tiny areas of the tools and then under the pressures of the moving chips had broken off those tool areas and carried them away. The results had been rapid tool wear.

With that chip welding stopped, cutting became more rapid and accurate. Studies which still are going on will make it even better.

It was found that under extremely heavy cutting pressures bits of some kinds of metal actually built themselves up on the cutting edges or "noses" of the tools. These "built-up" noses do not do the cutting—the tool alloy still does that—but they cushion and protect the tool. They also reweld themselves to the moving chips and are carried away, thus having to be replaced by more build up.

Modern studies are showing how to apply cutting oils so that the build up always will be constant, always the exact amount which will best protect the tool, while maintaining the highest cutting speeds and accuracies. What the results of this research will lead to, nobody knows. How soon the machinists and the cutting oil makers will make soluble oils do everything that straight oils are doing today, and drive straight oils on to new fields, nobody knows. But cutting oils, once seemingly on their way out, are still in the picture and here to stay.

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FIRE ALARM

Can Warn of Incipient Danger

COMING over the industrial horizon is a fire alarm which will detect a fire by the heat rays given off. The alarm, as announced by the National Board of Fire Underwriters, can have its sensitive or detecting element as much as 100 feet away from the fire. Once actuated by the heat rays it can sound an alarm bell, actuate a circuit which will warn the factory or the municipal fire department, or turn on a sprinkler head or shut off a machine to stop the danger.

Better still, such an alarm can be arranged to warn of incipient fires long before the blaze actually begins.

Radiant heat, especially if emanating from a black body, can sun-burn a man even though the emanating object is cold enough so he can easily bear his hand on it. And, from a great many objects, radiant heat may be detected long before they reach the combustion stage.

Burning is a type of chemical change which can take place slowly at temperatures far below those of actual combustion. The rate at which this change takes place in ordinary combustible materials doubles for just about every 18 degrees, Fahrenheit, of temperature. The approximate increase in this rate is shown in the table.

Rate of chemical change involved in the burning of ordinary combustible materials, with ordinary room temperature of 68 degrees, Fahrenheit, taken as unity

Degrees Fahrenheit	Rate Of Increase
68	1
86	2
104	4
122	8
140	16
158	32
176	64
194	128
392	262,144

A chemical change of this type tends to generate heat as well as be promoted by heat—a phenomenon aptly illustrated by the well known spontaneous combustion of oil soaked rags.

As the temperature rises, the tendency of the material to be damaged by the chemical change also will rise. Therefore temperature alarms which are actuated by heat radiations or by any other means such as thermometer bulbs are highly valuable in protecting materials in storage, process materials in vats, and the like. Moreover, the value of air conditioning in holding down damage to some stored materials is emphasized.

OIL QUENCHING

Made More Controllable With Additives

IN THE PAST, any engineer who had an exacting heat-treating operation to perform had his choice of two quenching mediums. He could quench in water and get such rapid cooling that he wrecked the steel, or he could quench in oil and get too slow quenching for the results he wanted.

Additives mixed with the quenching oils are ending this problem. With them the oil can be given any cooling ability (quenching speed) between that of ordinary oil and that of water, or can be made even slower than ordinary oil. Moreover, the oil blended with additives is far more uniform in performance and lasts much longer without changing its characteristics.

Plastics Sandwiches

Laminated Structures, Made of Glass Cloth Combined With Synthetic Resins, Have Proved Practical for Aircraft Sections. New Production Techniques Have Been Evolved Which Presage Wide Use of these Glass-Plastics Sandwiches in Many Industrial and Domestic Applications

A COMBINATION of plastics and glass broke into the news as a successful structural material a little over a year ago when engineers of the Air Technical Service Command at Wright Field announced the development of an experimental laminated resin-impregnated glass cloth sandwich fuselage for a BT-15 airplane. But from the point of view of the Army Air Forces there was one outstanding objection—the part employed a balsa wood core.

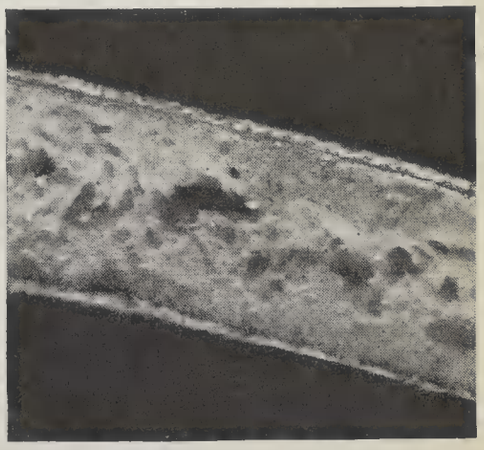
In contrast to the British, who used a completely wooden sandwich—a 7/16-inch balsa core faced with 3/32-inch birch plywood—for the DeHaviland Mosquito, the United States Army Air Forces have always considered wood a marginal material for combat aircraft which must operate under extreme weather conditions. Thus, with the wooden skin of the sandwich replaced with impregnated glass cloth, there remained the problem of finding some material to substitute for the wooden core.

The primary function of a core material is to stabilize the thin high-strength faces of a sandwich structure so that they develop a substantial portion of their ultimate compressive strength without buckling. What was needed was a low-density synthetic core with adequate strength, low moisture absorption, and dimensional stability—a material whose density and properties were uniform and controllable in manufacture.

In the search for a core material which would meet these requirements, the Air Technical Service Command at Wright Field carried out a series of tests on a variety of cores which fell under the following eight general classes:

1. Foamed thermosetting (phenolics, ureas, or copolymer) resins.
2. Foamed thermoplastic (cellular cellulose acetate, polystyrene) resins.
3. Foamed rubbers.
4. Foamed glass.
5. Foamed calcium alginate.
6. Gridded cores (honeycomb or square filled grid).
7. Impregnated fibrous cores.
8. Natural (balsa wood or cork).

The core they sought had to be strong enough in tension, normal to the surface, so there was no buckling of the glass fabric faces through tension failure in the core itself. Further, compression strength of the core material normal to the faces had to be sufficient to resist local loads usually encountered in service due to rough handling, such as a blow resulting from a falling wrench. Compressive strength needed to be such that the core would not fail before the faces of the laminate developed their maximum strength. Finally, the shear rigidity of the core had to be enough to hold the entire sandwich combination stable before the faces developed their full strength. At the same time, the core could not be brittle or granular since such materials possess poor impact and vibration characteristics.



Highly magnified view of section of a sandwich structure made with a foamed core. The high percentage of voids in the foamed resin is clearly evidenced

Construction material	Weight	Effect of 100 percent of design loads	Design load at failure (tail wheel side load)	Strength-weight ratio
	pounds		percent	
Aluminum alloy	70	No failure—visible buckling in some cases	105	1.00
Wood and plywood	86	No failure—visible buckling in some cases	110	0.82
Glass cloth laminate with wooden core sandwich construction	78	No failure	180	1.50
All resin-glass cloth laminate sandwich construction	75	No failure	180	1.55

Tabulation of results of static tests on airplane fuselages

TEST RESULTS—Compressive tests, tension tests, tests to determine relative flexural rigidity and ultimate strengths, and bending tests were carried out on specimens made up with cores falling into all eight classes listed above. The compressive stress developed in the glass-cloth facing material ranged from 8000 to 36,000 pounds per square inch, depending upon the core material and the thickness of the faces. Certain brittle cores such as alginate, which had reasonably high tensile strength, failed prematurely before developing maximum strength in the faces. Bending tests indicate that with cores of comparable properties, the strength and stiffness of the sandwich combination are more

dependent upon the physical properties of the core itself. All bending failures occurred in the compression face either by compressive failure of the face or by delamination (tension failure of the core).

Tests seemed to show that certain types of cores such as the Hycar cores, honeycomb glass cores, and cores of cellular cellulose acetate containing 3 percent chopped glass fiber had sufficient physical properties to develop a substantial portion of the compressive strength in Fiberglas cloth faces.

One of the results of this investigation was the construction by the Plaskon Division of Libbey-Owens-Ford Company, at the request of Wright Field, of an all-laminate rear section of a fuselage. Tests carried out on this structure and on aluminum alloy, wood, glass-laminate, and wood fuselages are compared in the accompanying table on the preceding page.

Four types of laminate construction were employed in this experimental fuselage, which was constructed in halves and then assembled. This two-part construction was followed, not because it was considered the most desirable procedure, but because a full fuselage mold was not available.

STRUCTURAL ADVANTAGES—The outstanding strength-weight ratio of this all-laminate construction, its smooth exterior surface, and extreme stiffness suggest that it will someday find extended use in the aircraft field. Aircraft designers have long recognized that substantially increased performance can be obtained if the exterior surfaces of aircraft can be made smoother and more stable. And when a structure is developed which not only offers these advantages but is adaptable to mass production as well, the possibilities are endless. Among the construction advantages which an all-laminate structure would seem to offer on the basis of the experimental fuselages built to date are:

1. Prefabrication — Component parts may be readily produced in widely separated plants and assembled as a complete structure in yet another factory.

2. Mass production — Sandwich core material may be readily corrugated and assembled, and cheaply produced with semi-automatic machinery in any desired weight and thickness.

3. Uniform results—Easy cure of the resin coupled with its tackiness makes it possible for the core, skins, and sub-assemblies to be easily placed and held in position. This also guarantees consistent production results.

4. Easily repaired—Damage by gunfire, for example was less for all-laminate construction than for either wood or metal. Another advantage is that repairs may be quickly carried out with no more equipment than is available in the field.

5. Material availability—The production of both the resin and the glass cloth, which is the basis for the all-laminate construction, can be readily expanded to meet all conceivable demands.

FOAMED CORES—All the tests which have been made on these sandwich structures with synthetic cores have not been confined to the laboratory. The Virginia-Lincoln Corporation, for example, is even now producing noses for fast fighter planes made up of plastic foam enclosed between inner and outer laminated glass cloth skins. For this application it was particularly important that the core have a specific gravity of 0.30, excellent weathering and electrical characteristics, and resistance to destruction caused by gun blast concussion. To date, the structures, which are made of Valenite using Laminac as the core resin, have met all the requirements very satisfactorily.

Following the step by step construction of one of these fast fighter



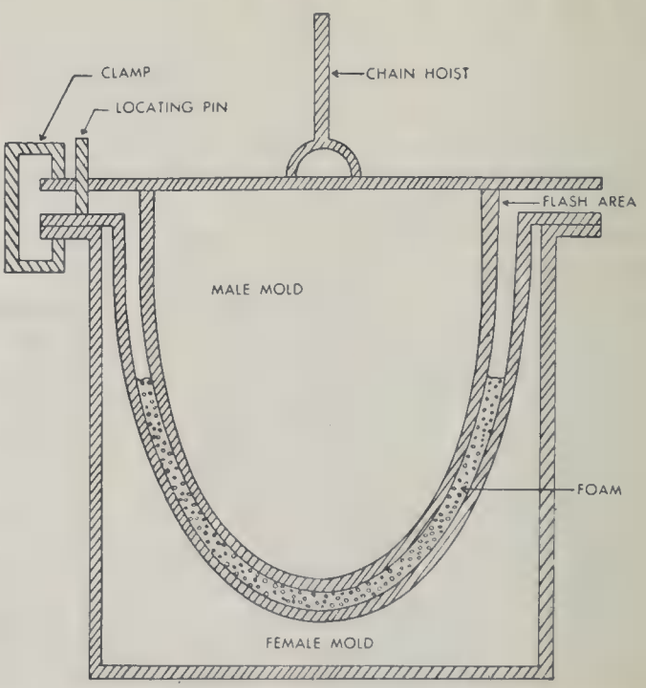
Lower left: Applying resin impregnated cloth and paper upon surface of mold to form inner skin of nose

Right: With outer skin in position in lower mold, upper mold with the inner skin attached is lowered into place ready to receive foamed resin

Lower right: Section drawing showing mold in a closed position with foam filling the space between the skins

Illustrations courtesy of the Virginia Lincoln Corporation



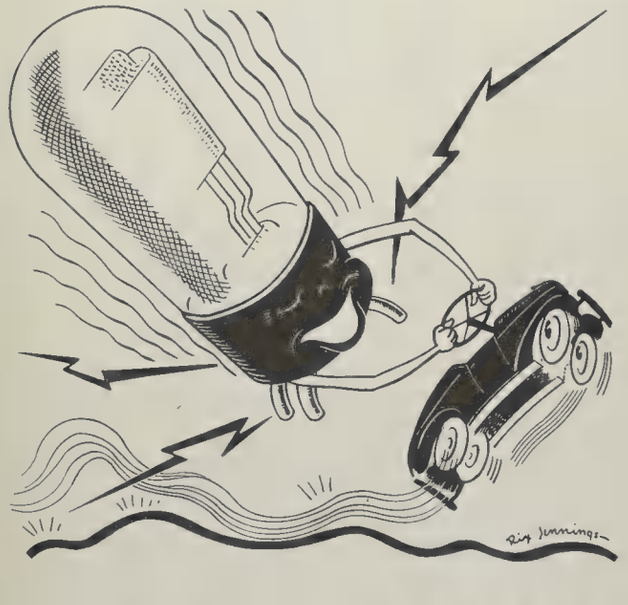


DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

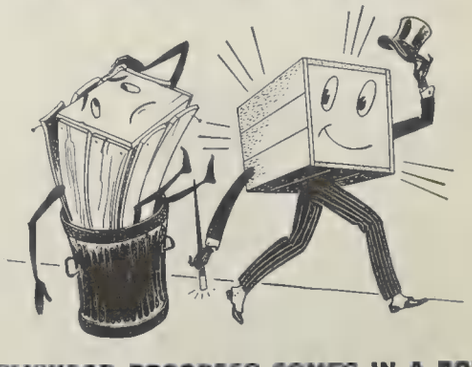
MOLDING COMPOUNDS



LAUGHING AT A LIFETIME OF HARD KNOCKS

The modern radio tube is a very delicate piece of equipment. Yet it must be able to stand up and render perfect service under the most rugged of conditions . . . such as in aircraft, boats or in your own car radio for that matter. The bases of thousands of these radio tubes are molded from Durez phenolic plastics. Such properties as impact strength, moisture resistance, dielectric strength, good moldability and excellent dimensional stability at temperature extremes . . . all of which are inherent characteristics of the more than 300 Durez phenolic molding compounds . . . make them ideal for such purposes . . . result in their use throughout the various fields of American industry on a scale that is practically all-embracing.

INDUSTRIAL RESINS



PLYWOOD PROGRESS COMES IN A BOX

Combine ease of manufacture with a finished product that has eyeappeal and tremendous durability . . . and you have the wartime-proved Durez resin-bonded plywood container. The unusual strength, and resistance to temperature extremes and moisture which Durez resin imparts to the rich beauty of plywood, make it a *natural* for the progressive manufacturer with an eye on post-victory markets.

OIL SOLUBLE RESINS



WHAT EVERY BUSINESS MAN SHOULD KNOW ABOUT KITCHENS

A kitchen is no nicer than its linoleum floor. Durez resins for linoleum prints impart gloss and extreme toughness to the natural beauty of the colorful inks used for this purpose — make the linoleum durable and almost wear-proof.

The field of plastics is a vast and confusing one — especially since wartime urgencies have brought to light many new and unusual applications for them . . . applications which proved plastics to be better suited for many jobs than any other material. One of the largest groups within this field is the phenolics — the type of plastics which Durez has specialized in developing and producing for the past quarter century. Out standing feature of the phenolics is their unusual versatility. *They are the most versatile of all plastics.* Naturally, this means a great deal to the manufacturer in the throes of improving his old products and developing new ones for post-victory markets — for the phenolics make a natural starting point in working out a plastic material problem. The background of Durez technicians includes a wealth of successful product development experience which covers practically all fields of industry. The benefits which this experience and a large accumulation of proved data can provide, are available at all times towards speeding the solution of any plastic material problem which you may have. Durez Plastics & Chemicals, Inc., 529 Walck Road, N. Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

noses suggests how adaptable this type of structure is to mass production. It is easy to imagine how this construction can be used after the war in the manufacture of low-weight furniture, refrigerator boxes, stoves, household insulation and, of course, aircraft..

For the manufacture of the fighter noses the equipment consists of cast-iron male and female molds, the contours of the male form exactly duplicating those of the female minus the thickness of the wall of the completed nose. A spacing mechanism is provided to facilitate the locating of the male form in the female form. As can be seen in the



A honeycomb core material such as is used in many sandwich-type structures. Made in blocks, cores can be sliced to suit requirements of any type of job

drawing, there is a flash area between the two molds at the top. This is provided so that pressure generated during the foaming operation can be relieved. In addition there are clamps which hold the molds together, a resin mixing unit, a trimming jig, and a thin laminated canvas male plug used in making the outer skin.

The manufacturer of the nose begins with the skins. The male form and the wrapping plug are inverted (nose-up) and covered with cellophane, which facilitates parting. The necessary lamination of impregnated paper and glass cloth for the inner skin are wrapped on the male form which is then covered with another layer of cellophane. To insure more uniform evacuation during the curing operation, a thin canvas bag, or "breather," is placed over the entire assembly. This construction is then covered with a rubber bag, properly sealed to permit evacuation. Upon the application of heat, through the mold, the inner skin is cured. Removal of the rubber bag, the canvas breather, and the top cellophane layer follows, exposing the cured inner skin laminate.

At the same time that the inner skin is being molded, the outer skin of impregnated paper and cloth laminations—is wrapped upon the cellophane-covered wrapping plug. Another layer of cellophane follows as with the inner skin. This done, the plug and the uncured skin are inserted in the female mold. The plug is removed, leaving behind the outer skin in proper place in the female mold. A rubber bag is inserted in the mold and the sealing lid put in place. With the application of heat, vacuum, and pressure the skin is then cured. Finally, the rubber bag and cellophane layer are removed, exposing the inner surface of the outer skin.

At this stage, the portions of the mold are readied for foaming. The male form is elevated with a chain hoist and placed in the "nose-down" position above the female form where, by rapid lowering, it can properly locate itself in the female form for the foaming operation.

The various components of the foam resin mixture are weighed out and cooled to a safe operating temperature. Next, they are carefully combined in a Hobart-type mixer. Within five minutes' time, a homogeneous mixture results.

With the molds ready, the foam mixture is poured into the female portion. Guided by the spacing mechanism, the male mold is lowered into position and the molds locked together. Within three minutes of the application of heat, the excess foam material starts escaping via the flash areas. Fifteen minutes later the curing is complete and the molds are cooled.

After the male mold has been raised, the foamed nose, which is securely bonded to its skins, is lifted from the female form and sent to the finishing area for trimming and painting. Due to the fact that this particular part requires a reinforced area for attachment to the airplane fuselage, portions of the foam and inner skin must be trimmed away and the inner surface of the outer skin exposed. "Beef-up," or reinforcing material, which consists of uncured impregnated glass fabric, is bonded so as to cover the section of foam which has been exposed. Curing of this material follows. Rough edges are then sanded away and the nose is sent to the paint department to be prepared for shipment.

The principles outlined in the manufacture of this nose are applicable to other items. The same general procedures were found to prevail in parts where specific gravities ranging from 0.20 to 0.80 were desired, where bearing and flexural strengths were stressed, where surface areas of 50 square feet and more were required. The desired properties were obtained primarily by foam formula variations; secondly by changes in equipment.

While all the work that has been carried on in developing suitable synthetic core material for use in glass-cloth sandwich structures has been for war, all indications point to the use of this type of structure in endless post-war application. Among these are such household items as stoves, refrigerators, and unit bathrooms and kitchens. The aircraft industry will undoubtedly find extended use for the construction. At the moment it is hard to say just what are the limits for these synthetic core materials for sandwich structures, or for the sandwich structures themselves.

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EAR PLUGS

Reduce Annoying Noises, Permit Conversation

INDUSTRIAL workers stand in constant fear of becoming deaf as a result of the constant loud noise that fills their working hours. To combat this hazard, John L. Brill and Associates has developed "Noise Masters" ear plugs, molded of Lucite. These plugs, which are fitted to the individual ear, are said to reduce the loudness of surrounding noises as much as 45 percent when the sound is in the low frequencies and as much as 65 percent when in the high frequencies. At the same time, it is reported, ordinary conversation at close range can be heard without difficulty.

BATTERY SEPARATORS

Now Made in the Form of Fiberglas Mats

FELTED Fiberglas is now being used in low-cost batteries of various types manufactured for Goodyear Tire and Rubber Company by the National Battery Company. In one model the felted glass fiber mats are placed on each side of every positive plate; in another model similar mats are wrapped entirely around each of the positive plates. The mats are made of finely spun glass fibers held together with a binding agent. Pores of the mats provide minute indirect openings, so small they permit passage of only very small spent articles of active material. Because active material is locked in the plates, the life of the battery is reported to be greatly extended.

Gas Turbine Possibilities

Will Airplanes of Tomorrow be Powered by Reciprocating Engines, by Turbo-Jets, by Turbines Driving Propellers, or by Some Combination of these Systems? Analysis of Present Technology Indicates that Each System Will Find its Place in Meeting the Varied Requirements of Flight

IF THE Germans had had six months more to put into production their V-1 and V-2 bombs, their airplanes equipped with rockets, and the turbo-jet, the whole course of the war might have been changed; the victory of the United Nations might have been indefinitely delayed. In the peace to come, it is probable that the turbo-jet (and, therefore, the gas turbine which is an indispensable element of the turbo-jet) will have, of these novelties, the greatest influence on modern aviation.

Within the last few months, there have been at least three fine papers on the gas turbine and its use in the airplane. S. R. Puffer and J. S. Alford, of General Electric Company, spoke of "The Gas Turbine in Aviation" before the American Society of Mechanical Engineers; Charles D. Flagle and Frank W. Godsey, Jr., of Westinghouse Electric Corporation, discussed "The Place of the Gas Turbine in Aviation," at a technical press luncheon; and C. F. Bachle gave to the Society of Auto-

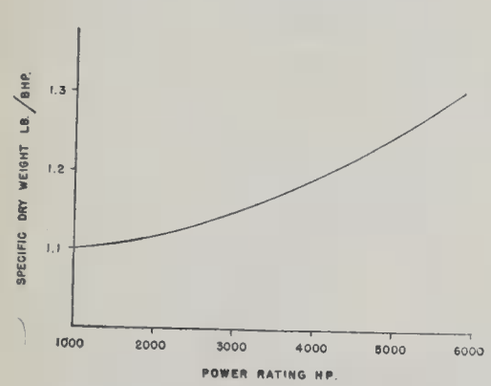


Figure 1. In reciprocating engines, the specific weight increases rapidly with size beyond a certain point

motive Engineers his thoughtful study of "Turbine Compounding with the Piston Engine." A forthcoming book by B. Hennlip, of Bell Aircraft, on "Modern Flight Testing" will also add greatly to knowledge.

From these sources, it is possible to understand and to evaluate the various embodiments of the gas turbine and jet reaction in the wholly modern aviation power plant.

The phrase "various embodiments" is used because it is now possible to offer quite a classification of aviation prime movers:

1. The conventional reciprocating engine and propeller—still the heart of aviation, still efficient, and improved when equipped with supercharger and water injection and utilizing the thrust of the exhaust to some extent by special design of exhaust outlets.

2. The turbo-jet in which air is compressed and forced to burn fuel in a combustion chamber. The exhaust gases drive a turbine that operates the compressor, and then rush out through a nozzle to provide a powerful reaction thrust. It is the turbo-jet with which Captain Whittle's name will be forever associated, and which has most impressed itself on the public's mind.

3. The gas turbine driving a geared-down propeller and utilizing the thrust of the exhaust to a marked degree; not yet flown, but certain of employment in the near future.

4. The compound reciprocating and turbine engine which Mr. Bachle has proposed.

There may be other combinations such as a conventional reciprocating engine acting together with a turbo-jet, with each functioning at the time appropriate to its best efficiency: reciprocating engine at take-off, and turbo-jet at great speed and altitude. But an evaluation of the four systems as above should give a basis of comparison for all possible combinations.

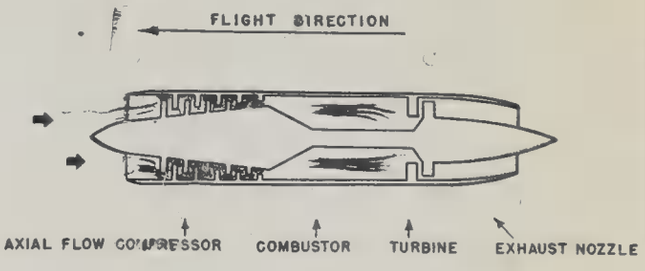


Figure 2: Simplified diagram showing the basic principle of an axial-flow turbo-jet

PROPELLER LIMITATIONS — Will the conventional reciprocating engine with propeller disappear like the horse and buggy? Not at all. In the history of technology, it is very rare that a new invention or improvement utterly displaces older appliances or vehicles. Thus, the Diesel locomotive has not and will not drive out the steam locomotive. The conventional reciprocating engine and propeller will continue to render excellent service in low- and medium-speed aviation for a great many years to come. It is when great speed is required, or great power, or flight at great altitude, or all three, that the reciprocating engine and the old-time propeller become less effective.

Here are the main reasons, as Messrs. Flagle and Godsey have so well put them: The reciprocating engine reaches its best weight figures at around 1000 horsepower, when the specific weight per horsepower is only one pound. In larger sizes, as Figure 1 illustrates, the specific weight will increase rapidly unless either more cylinders or better fuels are brought into action. The reciprocating engine functions most efficiently at 60 percent of its rated power, and that is a limitation on its use at full speed when full rated power is needed. Again, the very large reciprocating engine needs complicated controls so that not only does the specific weight of the engine itself go up with the

size, but the complete installed weight becomes excessive. Again, even the best air-cooled engine, with fine cowling, offers large frontal area and nacelle drag so that the net thrust per horsepower becomes disappointing. And, finally, at very high speeds, particularly at altitude, the propeller itself begins to lose efficiency because its fast

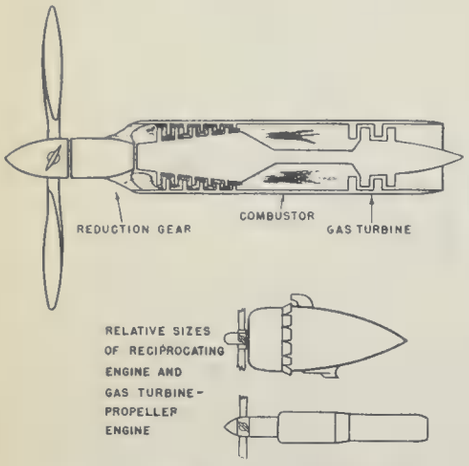


Figure 3: Diagram of a geared-down gas turbine driving a propeller, in combination with a turbo-jet unit

whirling tips approach the speed of sound. For all these reasons, it is possible to say that, unless and until many improvements are made, very high speed operation of aircraft would be limited by the deficiencies in the reciprocating power plant no matter how well resigned the airplane itself might be.

General Electric has been a pioneer in the development of the supercharger, and Messrs. Puffer and Alford, distinguished members of the General Electric family, rightly point out that when the exhaust gas supercharger, water injection, and exhaust thrust are employed, the reciprocating engine has, by far, the greatest overall efficiency where long-range flying is involved. But these refinements serve up to a point only. When super-aviation or flight at very great speeds is involved, the turbo-jet has to be considered.

Figure 2 illustrates, diagrammatically but clearly, the basic simple principle of the turbo-jet, in which an axial flow compressor is driven by a gas turbine. The axial flow compressor inducts the air, compresses it, and delivers it to the combustion chamber. There the fuel is burned at high temperature and constant high pressure. The compressed air and exhaust gases expand and drive the turbine and then leave the nozzle at the speed of sound, producing enormous reaction thrust.

When turbo-jets had to be built quickly, the AAF sought the aid of General Electric; the Navy called on Westinghouse. Both giant companies responded magnificently, and succeeded splendidly. If Westinghouse used the axial flow compressor, claiming to secure thereby the most direct flow, the lowest frontal area, and least aerodynamic drag, General Electric did equally well with a centrifugal compressor. To discuss the relative merits of axial and centrifugal compressors would need far more space than available here.

NET POWER—It can be seen from the above brief description that in jet propulsion, the whole net power (which is the difference between the power generated and the power used up in the compressor) is used to impart backward acceleration to the compressed air and exhaust gases. The question then arises: Why is the gas turbine so well adapted to jet propulsion?

The answer is readily found. As can be shown by simple applied mechanics, *jet propulsion is most efficient when the speed of the jet is not so far above the speed of the vehicle from which it issues.* This is a cardinal principle always to be remembered when thinking of jet propulsion. The gas turbine handles a great mass of air (four to eight times greater than the reciprocating engine) for each pound of fuel consumed. This is because the gas turbine swallows its own cooling air and subjects it to the same thermodynamic cycle as the air needed just to burn the fuel, while in the reciprocating engine the cooling air is used externally to the combustion space.

Because of this great mass of air handled, the exiting jet is cool and slow, and propulsive efficiency is far better than were the hot exhaust gases released from a reciprocating engine used for reaction thrust.

But when it is said that the exiting jet is cool and slow, relative terms are being used. To anyone who looks at a Bell Aircraft turbo-jet plane, or a Lockheed Shooting Star, the jet will appear to have tremendous speed and temperature. Accordingly, below 500 miles per hour, jet efficiency is very low and fuel consumption is very high. The thermodynamic or internal efficiency of the turbo-jet equipped with a good compressor may be 31 percent at 15,000 feet, which is of the same order as that of the modern reciprocating engine, but its propulsive or external efficiency is very low at take-off or climb and only becomes reasonable at the enormous speed of the fastest fighters.

JET ADVANTAGES — Does this mean that the turbo-jet will always be restricted to a special type of interceptor combat airplane where enormous thrust is required for only a short time and fuel consumption is unimportant? Not at all, because airplane speeds tend to go up all the time (unless compressibility effects bar further progress) and because the turbo-jet has so many other advantages to commend it. It is extraordinarily simple, there is no carburetor to ice up, no ignition trouble, no valve system to go out of order, no intermittent cylinder action, no overheating of the cylinder head or bearings. With a minimum of parts, the pilot can be completely assured at all times of a powerful, steady, continuous thrust. The turbo-jet is very light in weight, needs little lubricating oil, and is remarkably easy to maintain. This ease of maintenance has brought enthusiastic praise from all AAF personnel who have had experience with the engines. There are no radiators and no cooling surfaces. Frontal area of the engine nacelle is reduced to a minimum, so that the power-plant drag is reduced to a

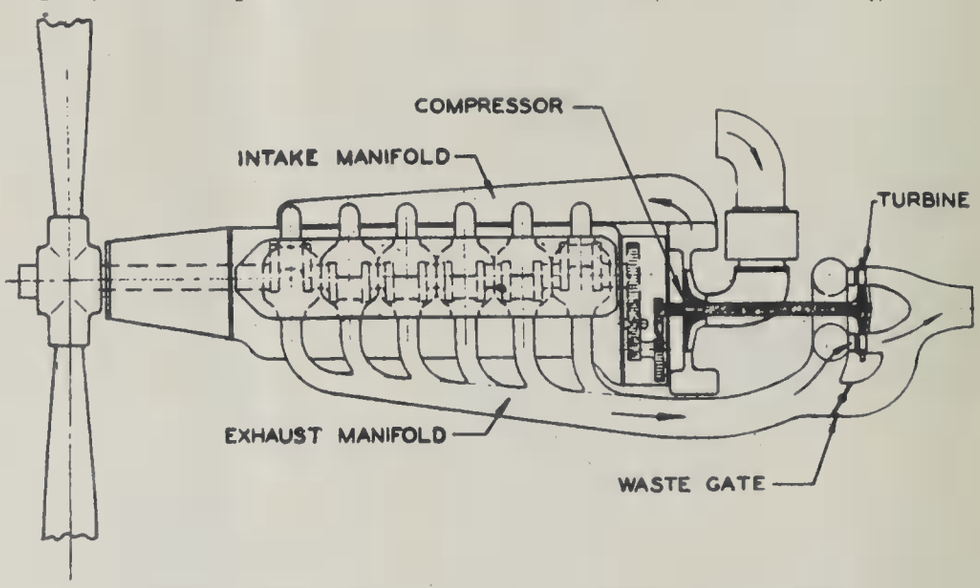


Figure 4: Bachle's compound reciprocating engine and gas turbine

minimum and the net thrust is a greater percentage of gross thrust than in the reciprocating engine. Since the jet is at the back of the airplane, noise in cabin or cockpit is reduced. There are immense potentialities of power, far beyond those of the conventional motor.

For these and other reasons, it may be expected that the turbo-jet will come into wide use reasonably soon—for planes of great speed or planes requiring immense power.

Messrs. Puffer and Alford bring up economic reasons to show that

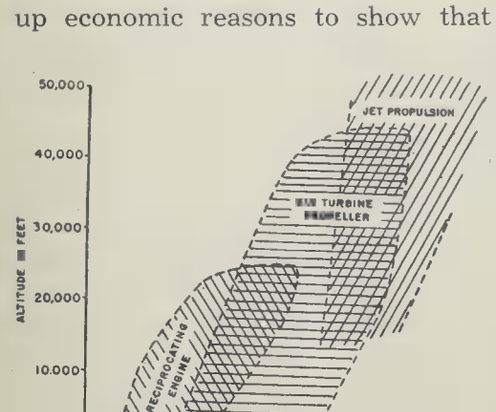


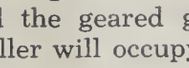
Figure 5: Estimate by Flagle and Godsey of probable spheres of action of various aircraft power plants

jet propulsion is *not* purely a military device. This is true because of the greater reliability of the turbo-jet unit, because of its higher rate of speed and consequently greater potential number of trips, because speed cuts down many items of airplane operating cost, and finally because the fuel required is not high octane gas but any one of a number of cheap fuels such as kerosine. *The cost of jet-propulsion transport is claimed to be only slightly higher than the cost of present-day transport for ranges of over 500 miles.* [See article by D. H. Killeffer immediately following this one for a discussion of jet-engine fuels.—*Editor.*]

A COMPROMISE—There is good reason to be optimistic as to the future of the turbo-jet engine—but wonderfully suited as it is to high speeds, it is *not* efficient at take-off, in climb, or even in long-range cruising. Is the combination of a gas turbine geared down to drive a propeller, in combination with jet reaction, a compromise more suitable to present needs? The combination is diagrammatically indicated in Figure 3. The geared-down turbine will constitute a beautifully symmetrical power plant, of small frontal area and low nacelle drag as compared with the reciprocating engine. Because of its small diameter the gas turbine will be easily buried within a wing. The geared-down turbine shares these and other advantages with the turbo-jet. But there is one advantage which the geared-down turbine possesses to a unique degree—versatility to suit a particular flight condition by varying the proportion of power developed in the propeller and in the reaction nozzle. Towards the lower end of the scale the propeller drive will be favored, with the exhaust jet thrust merely compensating for nacelle and cooling drag loss, and with high net thrust as the result. For high speed operation, 50 percent of the power would be developed in thrust, since jet reaction would then become efficient. Of course, the geared-down turbine loses some of the desirable features of the turbo-jet. It can no longer have the low slung body of the turbo-jet because of the propeller. Yet this intermediate type may have a broader field of usefulness than the reciprocating engine at one end of the scale and the turbo-jet at the other.

In Figure 4 is shown Bachle's scheme of compounding a gas turbine with a reciprocating engine, both working on the same shaft and driving a propeller. The combination is not intended for high speed, but because the gas turbine can take such excellent advantage of the exhaust gases, Mr. Bachle believes that the system would give excellent fuel-consumption economy and offer the minimum weight of power-plant plus fuel for long-range cruising at 300 miles per hour.

A tentative conclusion, illustrated by Figure 5, seems to be that the reciprocating engine will remain supreme for low power and moderate speed; jet propulsion will be superior at great altitudes and speed; and the geared gas-turbine with propeller will occupy an intermediate position.



POST-WAR FLYING

Jobs Raise an Important Question

WILL there be post-war jobs for wartime pilots? Phillips J. Peck discusses this question in *Flying,* basing his discussion on an appraisal of the situation by Paul E. Young of the Civil Aeronautics Administration.

At the conclusion of the war, the Army alone will have 100,000 "top-grade" combat pilots and 50,000 Air Transport Command instruction and service pilots. Of this number, 75,000 may be discharged at the end of the war. The Navy, Marine Corps, and Coast Guard discharges will raise this total above the 100,000 mark. To this number must be added men in the Civil Air Patrol, and those already employed on the airlines. The Army does not intend to stay in the air-transport business, and thus eventually the Air Transport Command will dump its entire personnel back to the airlines.

But in the war effort the airlines —TWA, United, American, Eastern, Pan American, and others—have utilized their Air Transport Command units to build up a gigantic reserve of well-trained pilot personnel. It is, according to Mr. Young, a physical and economic impossibility for these thousands of pilots to be absorbed in post-war civil aviation, no matter how great may be its growth.

It is Mr. Young's opinion that some 39,000 men will find civil aviation employment: 4000 on the airlines within two years after the war; 15,000 in the flying schools; 20,000 in miscellaneous services. Miscellaneous services will cover feeder-pickup, charter services, crop dusting, forest patrol, aerial survey work, air advertising, lake stocking, and so on. This is a very reasonable view of the situation and it is far better that many of our Army and Navy pilots should regard their flight training as a delightful accomplishment and avocation, rather than a postwar professional activity.

SCRAP RECOVERY

May be Speeded by Chemical Process

IMMENSE quantities of aluminum in airplanes that must be scrapped at war's end for one reason or another pose a tremendous salvage problem because of the complexity of the parts. Separation of pure aluminum from alloying elements and from parts composed of other metals is impracticable by ordinary methods. However, a chemical recovery process promises to solve the problem economically and efficiently by dissolving the aluminum away from other materials present by the use of a solution of caustic soda. This solution readily dissolves aluminum but not the elements with which it may be alloyed and it leaves steel, copper, and other metallic parts unaffected. Furthermore, the solution of aluminum as sodium aluminate readily yields the metal in the form of its oxide in exceptionally pure form for introduction into the electrolytic cell for recovery. Naturally, only composite parts left after large pieces of pure metal have been cut away will need to be subjected to this treatment.



Photo by Air Technical Service Command
A B-25 using rockets for assisted take-off

CHEMISTRY IN INDUSTRY Conducted by D. H. KILLEFFER

Fuels For Jets

Reaction Engines for Aircraft Seem Capable of Operating Efficiently on Simple Fuels. But it May be that this Simplicity is as Yet Due to a Lack of Knowledge of the Means for Obtaining Highest Efficiency from the Power Plants that Will Operate the Aircraft of Tomorrow

Now that production of huge volumes of aviation fuels for conventional internal-combustion engines is an accomplished fact, industry faces new problems in providing fuel for tomorrow's rocket-powered aviation. Experience so far gained with the toys of 1930's dreamers shows that jet and rocket power will ignore the criteria vital to today's flight and will impose new requirements on the producers of fuels for tomorrow's planes. It is all quite confusing. No sooner have high compression, octane numbers, and super fuels taken their industrial places than the new needs of advancing aviation suddenly discard these and promulgate new specifications for new types of planes operating without propellers. It is worth looking into, for these new needs will profoundly influence trends in the fuel-producing industries for the future.

At first blush the fuel needed for jet propulsion appears much less limited by essential requirements than that powering today's conventional engines. Obviously the basic differences between the two types of engines are reflected in basically different specifications for their fuels. Whereas volatility (except with the new "safety gasoline"), octane number, and high compression characteristics are paramount requisites of internal-combustion reciprocating engines, none of these is of any particular consequence in either jets or rockets of the present day. The specific requirements of today's aviation fuels are inherent in the design and operation of the internal combustion engine itself. Secondary restrictions imposed by the operation of the engine in an airplane are minor as compared with the necessities of the engine's fuels.

Quite the reverse is true of rocket fuels. The rocket or jet imposes no particular restrictions on the fuel that are not easily met by existing petroleum products. But, on the other hand, the extraordinary characteristics of jet-propelled planes, with their possible use at otherwise unattainable altitudes, emphasize the importance of the plane's requirements in the selection of a suitable fuel. Instead of volatility, high octane number, and high compression characteristics, jet-popul-sion engines emphasize the need for high energy content, low freezing point, and high flash point as the most important qualities in their fuel. That change completely alters the problems of production and refining of fuel, but in spite of the apparently wide latitude thus allowed, vexing problems still remain for industry to solve.

REACTION ENGINE TYPES—To make the matter clear it will be well to examine broadly the characteristics of jet-propulsion engines to learn how they function and what are the controlling factors in their operations. Much of the current development of engines of these types is of such military importance that many details cannot yet be revealed for security reasons. But, nevertheless, enough of a picture can be

drawn to indicate the trend, if not the detail, of future developments.

First, two broad types of reaction engines must be distinguished. One is typified by the old-fashioned skyrocket and is properly designated as a rocket. Rockets carry with them both fuel and oxidizing agent with which the fuel is burned, and may be powered by either solid or liquid fuels (smokeless powder and gasoline are typical). Numerous types of rocket projectiles have proved valuable weapons in the present World War. A second type of reaction engine carries its own fuel but depends on oxygen from the air to burn it and on the air stream to provide the required forward thrust by its thermal expansion. The buzz bomb loosed on England by the Germans and the several types of jet-propelled planes typify this second class of reaction engines. These have been designated as air-stream engines or jets to distinguish them from the true rockets of the class previously mentioned.

Developments thus far in rockets, as defined above, indicate severe limitations on their value as the principal motive power of cargo carrying planes. Extreme temperatures and simultaneous high pressures are encountered in their operation and for practicable efficiency these mount beyond the ability of any known materials of construction to withstand them. This has been shown by both practical tests and theoretical calculations. Hence, for the purposes of this discussion, these interesting engines may be passed over as impractical for any but special uses. Their fuel requirements are best met by liquid atomic hydrogen, so far unattainable, and liquid oxygen. Other fuels consist of smokeless or black powder, various hydrocarbons and alcohols (including gasoline, kerosine, ethyl alcohol, and so on) with liquid oxygen, hydrogen peroxide, or nitric acid as the oxidizing agent.

These rocket engines are useful for throwing explosive charges over short distances as demonstrated by the bazooka and other types of rocket projectiles used in the present war. Perhaps their utility may be tremendously extended in the future, but the extension will have to be very great indeed to bring them within range of practicability as a means of transport of human beings or cargo. The case is presented with absorbing interest by G. Edward Pendray in his book, "The Coming Age of Rocket Power," lately reviewed in "Our Book Corner." To it the reader is referred for more information on the subject.



Photo by U. S. Army Air Forces

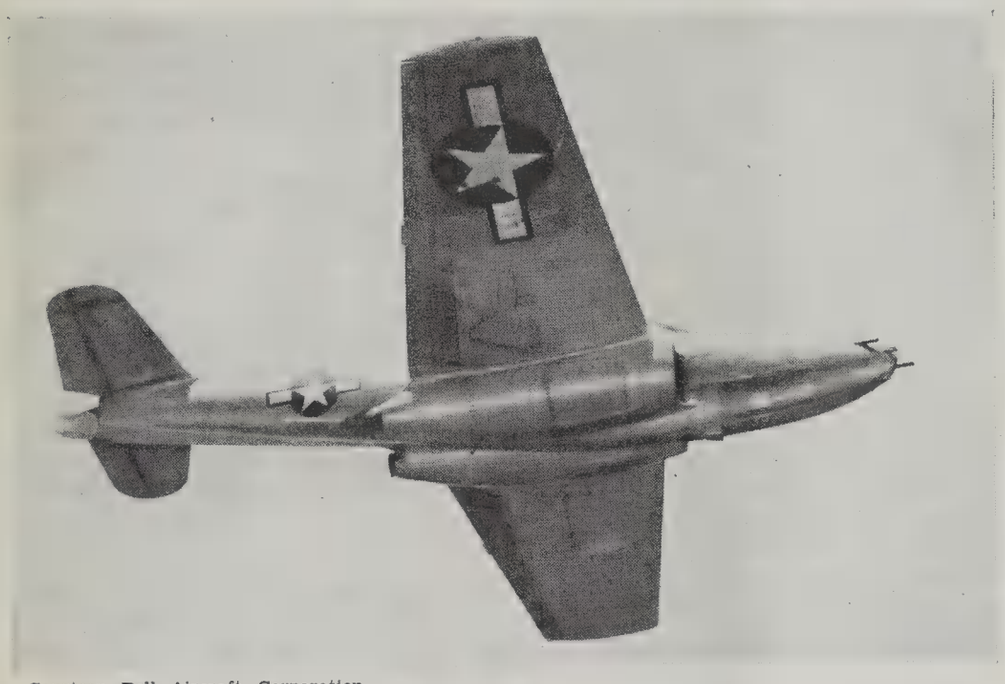
A complete German robot bomb found intact in France

PRACTICAL JETS—The air-stream motors present a different picture. Already they have been utilized both for human flight and for transporting substantial cargoes of high-explosive bombs. Both applications seem already to have come so far within the range of practicality as to suggest here an analysis of their fuel requirements as a problem in production in the near future.

Pendray divides air-stream motors into three sub-classes: thermal or turbo-jet, intermittent duct (buzz bomb), and continuous duct (also called the athodyd). The first draws in air through a turbo-compressor driven by a turbine powered by the flaming jet itself, and ejects the air expanded by the heat of the flame from a rear orifice. The continuous duct engine depends upon the ram effect of its speed to supply air to its flame which continuously heats and ejects the expanded air. The intermittent duct engine operates on the same principle except that the fuel is exploded within its body intermittently, a number of check valves in its forward end admitting air but preventing the combustion products from escaping except toward the rear.

Each of these has both advantages and disadvantages. Although the turbo-jet involves the complication of a turbine and a turbine compressor driven by it, this form seems at present to enjoy greatest favor, temporarily at least. An alloy capable of withstanding temperatures up to 1000 degrees, Fahrenheit, more or less continuously and without undue warping, oxidation, or erosion made possible the turbo supercharger employed on high flying planes. This alloy is also essential in the construction of the turbo-jet air stream engine employing several parts virtually the same mechanically for very nearly the same purpose as in the supercharger. The extreme temperatures of the true rocket are avoided by dilution of the flaming mixture with an excess of air.

Both the intermittent and continuous duct engines are simpler, involving no moving parts, but while simplicity is advantageous, lack of compression requires that



Courtesy Bell Aircraft Corporation

The P-59, AAF jet-propelled fighter, in flight

both of these engines reach relatively high speeds before they will operate satisfactorily. Speed is necessary to force air into the combustion chamber and without this the engine will not function effectively.

FUEL REQUIREMENTS—From a fuel point of view, these three types of air-stream engines are alike. It is only necessary that the fuel pos-



THE THERMAL JET ENGINE (TURBO-JET)



THE INTERMITTENT DUCT ENGINE (BUZZ BOMB ENGINE)



THE CONTINUOUS DUCT ENGINE (ATHODYD)

Reproduced by permission of Harper and Brothers from Pendray's "The Coming Age of Rocket Power"

Three types of airstream engines

sess high heating value and that it be capable of being fed continuously to the combustion zone. Practically, this means that the fuel must be liquid under the conditions of use. The feeding of solid fuel, even in finely powdered form, involves complicating mechanism, and gaseous fuels occupy unduly large volumes per pound or per heat unit. Fuels which are gases at ordinary temperatures and pressures can be used in liquefied form provided the weight of the container necessary to hold them is not too great for practical purposes.

These are the only ruling criteria involved in fueling jet planes. Clearly a great number of present commercial fuels meet them well. There are, of course, other specifications so desirable from a practical standpoint as to be virtual necessities. The fuel must be free from solid abrasive particles that would erode the mechanism, a requisite both of the raw fuel and of the products of combustion. The presence, for example, of silica or of combined silicon that would burn in the flame to silica is a serious drawback to any fuel. Soot at high velocity is also harmful. Other elements yielding similarly abrasive oxides must be excluded. The fuel must remain liquid at the low temperatures encountered in flight at high altitudes. This requirement is readily met by many, but by no means all, of the commercial hydrocarbon fuels. Easy flow at temperatures down to the required point of —80 degrees, Fahrenheit, is characteristic of gasolines and naphthas, but even some kerosines become sluggish or actually congeal in this low temperature range.

Also desirable to a point approaching necessity is a high flash point for the fuel. The flash point is defined as the temperature at which the fuel is sufficiently volatile to form a combustible mixture with still air. The higher the flash point of a fuel, the safer it is to carry in a plane. The flash point of ordinary gasoline is below normal atmospheric temperatures and thus its use involves at best a certain hazard of explosion which is particularly great in military planes in combat. Consequently the specifications for fuel used in any military plane call for as high a flash point as practicable. In jet fuel, this can be 105 degrees, Fahrenheit. If the flash point is made too high the fuel is likely to freeze under operating conditions and conversely too low a required freezing point leads to the inclusion in the fuel of hydrocarbons which unduly lower its flash point. Flash point is connected with volatility and a low flash point is necessary for the proper vaporization of a fuel in a carburetor, which is not required by jet engines.

SPECIAL FUELS—The criterion of a clean fuel which burns without considerable residue is easily met, but the combination of low volatility, and consequently high flash point. with an excessively low freezing point, is sometimes considerably more difficult to meet with practicable fuels. Either requirement alone would permit the use of immense volumes of petroleum products already available, but the combination of the two in a single fuel practically requires that it be especially refined for the purpose and thus places it among the special fuels.

Also essential to the efficiency of a fuel in jet engines of present design is the ability of the fuel to burn in dilute mixtures with the large volumes of air now used. Every combustible substance requires a definite proportion of air for its complete burning and it will burn in mixtures both more concentrated and more dilute than the ideal. However, outside a definite characteristic range of concentrations, it will not burn at all. The requirement of high dilution to keep temperatures down in jet engines limits usable fuels to those capable of burning at dilutions necessary to meet temperature restrictions. While this adds to the complexity of the fuel problem it still leaves a wide selection available to the engineer to power his future aircraft.

Perhaps the reason the jet fuel problem still seems relatively simple is that we do not yet know enough about it. The first automobiles were powered by the waste naphthas of kerosine refiners and it was only after decades of operation of millions of cars that efficiency and the factors affecting it became important. This may also be true of jet engines and future developments may show the need for special qualities in their fuel now unsuspected in our present knowledge of the subject. Research in the field proceeds at a swift pace because of its bearing on the military situation. When need comes, chemical industry's petroleum refining division will be ready to meet it. Meanwhile it looks simple, simpler probably than it is.

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PEPPER

Alkaloid Used In Insecticides

RECENT tests indicate high insect-killing efficiency for insecticides containing piperine, alkaloid of black pepper. Combinations of piperine with the pyrethrins extracted from certain flowers showed unusually high killing efficiency when used against house flies. The purified piperine alkaloid is relatively non-toxic and non-irritating to persons.

MERCURY FUNGICIDE

Is Soluble in Paint And Varnish Vehicles

DESTRUCTION of materials by mildew, mold, and rot has been emphasized by the Pacific war and this has developed new and urgent demands for fungicides having various properties. Latest additions to those available are the pyridyl mercury compounds containing mercury in a particularly effective form and available as several different salts having different desired solubility characteristics. Pyridyl mercuric stearate, for instance, is soluble in paint and varnish vehicles to an extent that affords excellent protection against tropical destruction. The chloride and the acetate possess advantages for treatment of textile and fibrous materials. Studies conducted both in the laboratory and in the field indicate great effectiveness for compounds of this group.

Glass and Electronics

Glass Has Played a Vital Role in the Development of Electronics. Now Electronics is Reciprocating by Providing a Flexible Tool for the Glass-Working Industry Whereby Welded Glass Products Can be Produced With High Precision and Sharply Localized Melting Areas

By VIN ZELUFF
Associate Editor, *Electronics*

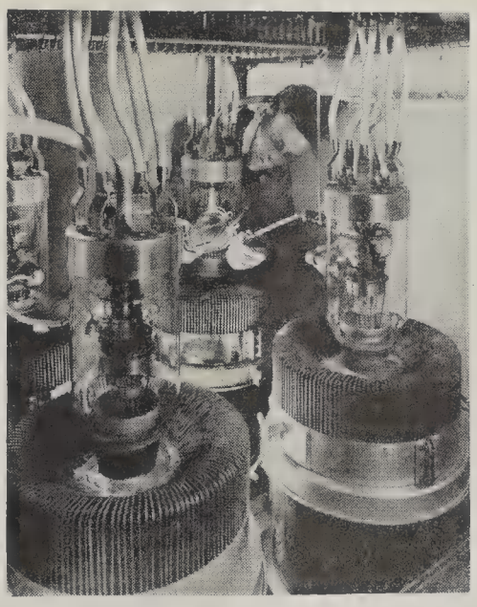
GLASS enabled Edison to produce his first incandescent lamp, in which the "Edison effect" was observed. From this beginning, Fleming, Wehnelt, Reisz, von Lieben, and De Forest all used glass as the containers for their first electronic tubes. By 1934, 55 million glass tubes were being manufactured annually.

A skeptical industry and public first saw metal vacuum tubes, made of steel, in 1935 and this seemed to herald the last days of the use of glass in electronic units. This was not so, however, for each one of the metal tubes contained glass. Less glass, to be sure, than formerly, but still highly essential glass.

In any vacuum or gas-filled tube, there must be wire leads or conductors connected to the electrodes. These must extend through the shell, metal or glass, to permit the tube to become a part of an electrical circuit. In the glass tube, the glass itself is an insulator and no problem exists in making proper connections. In the metal tube, however, the conductivity of steel does not permit bringing the leads through directly. Instead, an insulating bead or sleeve around the wire is necessary. For this purpose, glass is the best material. Thus, even in the metal tube, glass still is necessary.

Metal vacuum tubes contain a "header," which is the stamped and perforated foundation of the tube. Metal eyelets, of Fernico, are inserted in the perforations and welded to the header. Glass-beaded wires are then inserted in the header eyelets and the assembly carried through gas flames which melt the glass beads and form a permanent air-tight seal between the glass and the metal. After assembly of the element structure (the grids, plate, and cathode), the outer metal shell is fitted over the complete element structure and welded to the header. The tube is then ready for the evacuation pumps.

STRESSES—Sealing of glass to the wire leads was solved in the early days of vacuum-tube research by W. G. Housekeeper, of Bell Telephone Laboratories. When glass and metal are heated together and allowed to cool, if the glass contracts differently from the metal a stress is set up which may cause fracture. If the seal is to be made air-tight, the glass must match the metal very closely in its thermal expansion coefficient. The Housekeeper seal lent itself to quantity production and was quickly adopted. In this technique, the copper wall at the joint is made very thin so that the copper can deform enough to compensate for the differential in expansions. The thin wall is formed of a scale of cuprous oxide on the copper wire which fuses together with the glass sufficiently to give a vacuum-tight seal.



Glass envelope and stem assembly of 50,000-watt Westinghouse radio transmitting tubes. In this air-cooled type, the anode is the flanged base through which air is forced by blower

Tubes are not the only radio and electronic components that have benefitted from the use of glass. Condensers, too, in the early wireless equipment, contained sheets of glass between metal plates—an industrial version of the Leyden jar. Radio coil forms are now produced of glass that have a plus or minus constancy of diameter and pitch of one thousandth of an inch. Today a new glass-molding technique, the multiform process, allows glass to be molded into shapes that would not otherwise be possible.

A valuable development brought about by war research is a glass jewel bearing used in meters and instruments of electronic equipment. Sapphires, which were used for such bearings, were manufactured by hand abroad. Now a glass has been developed which can be used for instrument bearings. This glass substitute may replace the jewels because it is better in certain applications.

GLASS HEATING—In conventional heating of glass by glass-working fires, the material is heated through the surface. The surface boiling and destructive loss of volatile constituents in this method limit the heating speed and the size and thickness of the parts that can be heated. Recently conducted experiments

made with electronic heating equipment have shown that, given the proper conditions, glass can be heated electronically in three different ways; by dielectric heating, by induction heating, and by electrical conduction through the heated glass with gas-flame electrodes. The best method for a given application is determined by the nature of the particular operation to be performed, the properties of the glass to be heated, and the temperature range required in the processing treatment.

Although glass has high dielectric value, and is, therefore, a good insulator, induction heating has been used in an indirect method of perforating the glass envelopes of cathode-ray tubes used in radar equipment, and as the picture tube in television receivers. In these, a connection must be made from an internal element to a metal cap at the side of the tube. The perforation for the cap is made by placing a metal slug inside the glass envelope at the spot where the hole is to be made. The cathode-ray tube is then positioned at an electronic induction heating outfit so that the metal plug is heated sufficiently to melt the glass wall of the tube and it drops through the glass, leaving a perfectly round clean hole. The metal connection cap is then placed in position and its periphery sealed into the glass wall.

A method of welding glass by the passage of high-frequency current through a restricted area where it is to be softened and flowed was recently described by E. M. Guyer of the Research Laboratories of Corning Glass Works. In this technique, advantage is taken of the fact that glass, although normally a non-conductor of electricity, will permit the passage of electric current when heated.

Flames from small oxyhydrogen burners are used to preheat the glass parts to be welded. The flames are very small and sharp and restriction of the preheated area can be closely regulated. The preheater flames are too small to melt and work the glass, but they can and do raise the temperature of the glass to the point where it ceases to be an insulator and becomes a high-resistance conductor. This happens at temperatures below the melting point and thus avoids destructive surface boiling.

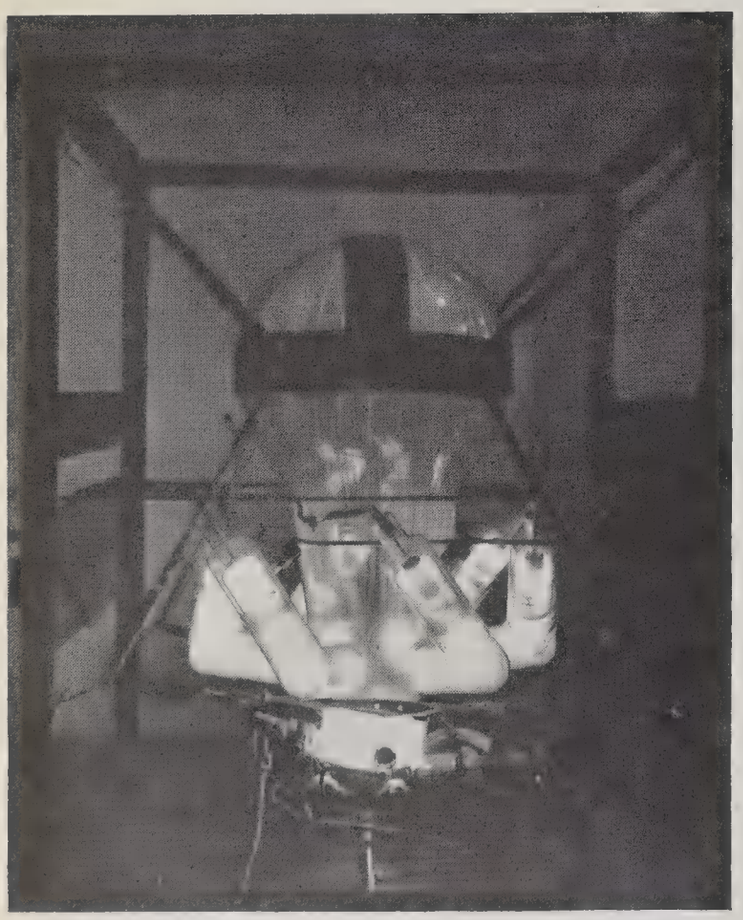
The flames next serve as gaseous conductors to direct high-frequency currents from the metal burner tips to the conducting paths already established in the glass by the localized preheating operation. Since the pin points are velocity directed, they impart controlled direction to the high-frequency discharge passing through them to the glass, thus serving as flexible, non-sticking, electrical brushes.

The combination flame-electrodes also serve as variable resistances in series with the glass load, and exert a certain degree of control over the flow of the high-frequency heating current as they are moved closer to or farther away from the glass.

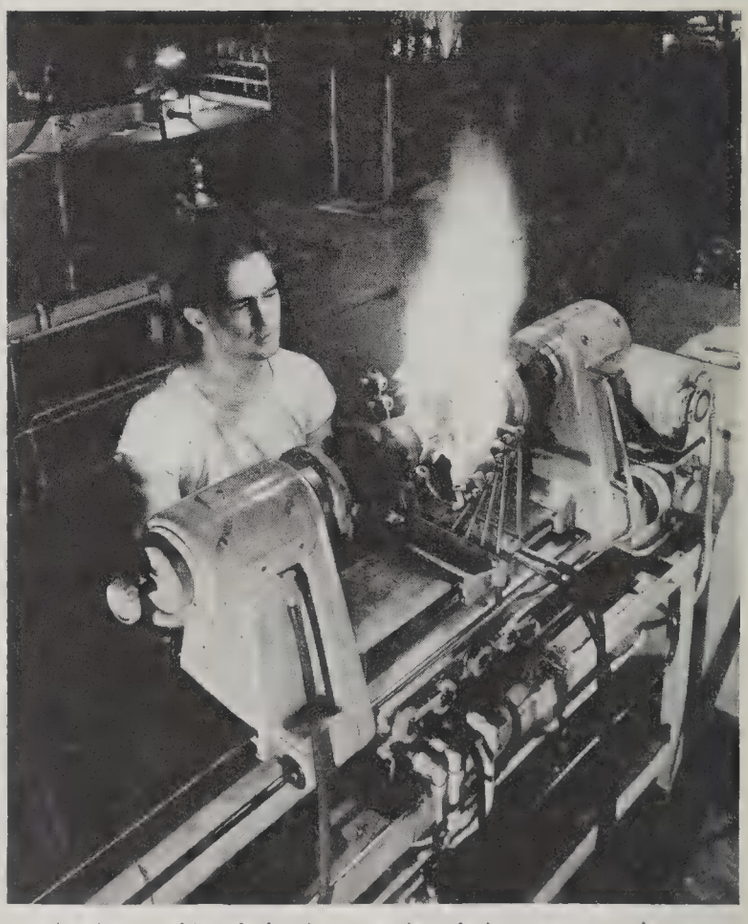
The high-frequency current passing through the preheated paths in the glass produces a much greater heating effect inside the material than the small preheat flames which started the process, and variation of the welding current provides exact regulation of glass temperature. Similar electrical high-frequency cross-fire systems have been applied with success not only to hand-welding operations and to rotating electrical sealing lathes but also to automatic machines.

WELDED GLASS PIPES—Glass pipe lines have been developed that use a cleverly designed and carefully engineered flanged-joint system. This permits convenient lengths to be coupled and clamped together in the process of assembly. In certain types of service, however, an all-glass, one-piece pipe line system has very definite advantages.

Because of the high melting temperature of thick-walled borosilicate glass pipes, the process of sealing together lengths of pipe with no other tool than a conventional glass-fire is a tedious, time-consuming job requiring great skill on the part of the glass worker and resulting in a costly installation. The high-frequency cross-fire method was recently used successfully to weld all-glass pipe lines. The simple portable equipment developed for this purpose makes possible for the first time



Photographed during operation, this mercury-arc rectifier in Allis-Chalmers equipment supplies 100 kilowatts of power

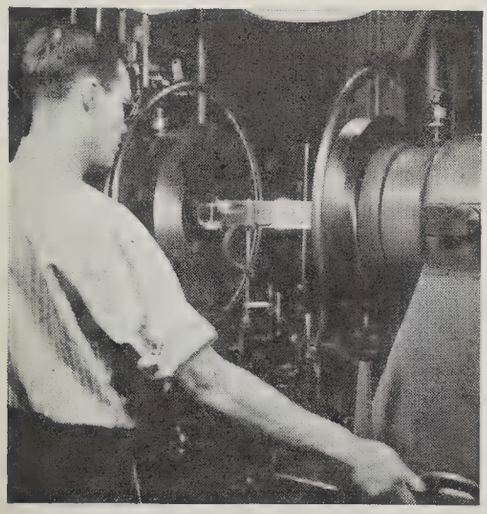


A glass-working lathe in operation during one step in assembly of a high-power Federal transmitting vacuum tube

the rapid installation, repair, and servicing of all-glass lines of any length in the field.

The ends of glass pipe are prepared for welding by removal of irregular edges with a conventional hot-wire crack-off tool. The same instrument permits removal of a damaged section from a service line, preparatory to rapid repair by welding in a new section cut to length at the site of the installation.

Pipe sections to be welded together are mounted in accurate axial alignment on a clamping jig with the ends slightly separated. A small toggle lever permits free, easily con-



Glass-sealing lathe with electronic cross-fire gun developed by Corning

trolled manipulation without loss of axial alignment and provides the necessary means for the smooth application of welding pressures, or for the application of stretching forces to remove excessive upset.

The two glass faces that are to be welded are pre-heated by the pin-fires at the tips of the welding guns until the glass becomes conducting. Two skilled operators are located opposite each other so that both sides of the weld can be critically inspected at all stages of the operation. When they move the hand guns to and fro in slow rotary oscillation, the pipe ends reach a uniform, barely visible dull red.

Next, high-frequency electric heating is started and rapidly melts the two pipe sections together, while pressure is applied with the toggle lever and followed, immediately after the high-frequency power is shut off, by blowing and stretching to reduce the upset. Annealing then eliminates strains.

High-frequency sealing on rotating machines demands less skill on the part of the operator since uniform heat distribution to the work is provided by the mechanically synchronized, regular, and continuous motion of the glass parts as they rotate in the cross-fire.

Experience in the systematic performance of a sequence of properly timed steps and judgment of glass temperature are necessary in the operation of high-frequency glass sealing lathes. Mounting and centering irregular pieces on the rotating heads accurately enough to avoid wobbling and fast enough to keep up with modern production schedules likewise require practice.

AUTOMATIC OPERATION—Fully automatic machines into which glass parts are loaded and from which completely finished, electronically welded glass products are unloaded are now in operation. Electronic high-frequency sealing can be applied to many different glasses and many different kinds of glassware with important advantages over conventional methods. High-frequency generators are more expensive than gas burners, however, and there are many operations where electronic heating does not show sufficient improvement over gas to warrant the extra expense. For example, when close heat restriction and control are unimportant, there is little to be gained from the new methods.

In operations where melting time is a significant factor in total production time, and where accurately controlled and sharply localized melting can produce a superior article or perform a desirable operation which otherwise would be impossible, the electronic techniques have no equal.

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PIPE FINDER

Can be Used to Locate or Measure Magnetic Fields

Called the Gradientometer, a new indicating unit quickly locates magnetic fields and hence is useful in aircraft inspection, in locating lost tools and underground piping, in searching for conduits, and so on. It cancels out uniform magnetic fields, such as the earth's field, and is designed primarily to locate magnetic gradients. It is easily converted into a Magnetometer that may be used to measure the strength of magnetic fields.

MOLTEN METAL

Pouring Controlled by Phototube

In one foundry, a single operator working from a remote station governs the pouring of several ladles simultaneously with the aid of a photoelectric control that automatically tips the pouring ladle back when the mold is filled. The heat, splashes of molten iron, and other hazards encountered in hand pouring are completely eliminated and several molds are now poured in less time than was needed to pour one by the former method.

As each group of empty molds moves into position before a ladle, a photoelectric control mounted directly above watches the riser opening through a viewing tube. When the molds are in place, the operator, through pushbutton control of the hydraulic actuating mechanism, tips the ladles of molten iron and the white-hot metal flows into the molds. As it reaches the riser of each mold, the brilliant light thrown off by the molten metal signals the phototube that the mold is full. The electronic unit causes the ladle to drop back and the pouring automatically stops.

These photoelectric control units were made by Photoswitch, Inc., and installed in a foundry of the American Brake Shoe Company.

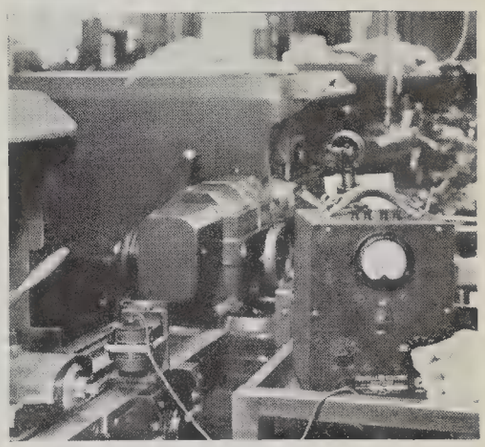
VIBRATION

Located by Use of Electronic Pick-Up

Cause of vibration in grinding machines at the plant of a manufacturer of high-precision taps has been located by an electronic instrument. The vibration in one machine in particular was causing a large number of rejects.

A G-E electronic vibration velocity meter revealed that a set of gears in this machine, apparently in good condition, caused the vibrations. Replacing the gears eliminated the difficulty.

The meter was also used for detecting low-vibration areas in the



Electronic vibration detector at work

plant as a guide in placing new equipment.

The meter consists of a vibration pick-up and electronic amplifier which measures vibration velocity and, together with an integrating unit, vibration displacement.

Glass-Metal Collaboration

From Mirrors to Industrial Pumps, Various Combinations of Metals and Glass Have been Developed to Serve Specific Purposes and to Solve Difficult Problems. The Electrical and Chemical Industries Find Many Uses for Such Partnerships, Retaining the Best Features of Each

By KENNETH ROSE
Engineering Editor, *Metals and Alloys*

At first thought glass and metals might seem as incompatible as oil and water. Most common metals are strong, opaque, tough, and capable of a degree of cold-working, while glass shatters at a blow, is ordinarily transparent, and cannot be cold-worked at all. Yet in the unending search for new materials, industry has joined these unlikes in literally hundreds of uses, not merely in association with each other, but actually blended into unit materials.

In 1835 a German chemist, von Liebig, heating acetaldehyde with ammoniacal silver nitrate in a glass vessel, noticed that a deposit of metallic silver formed on the glass. Five years later the process came out of the laboratory as one of the most familiar articles in which glass and metal form a unit—the mirror. Since von Liebig discovered the method for silvering glass, dozens of variations of his process have been invented.

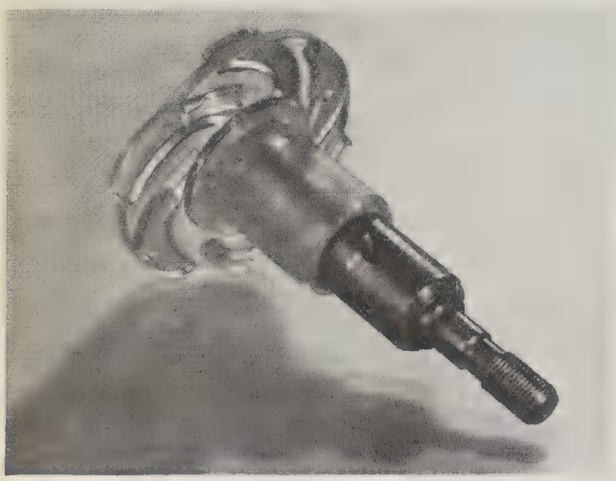
In the usual industrial process for making mirrors today, the glass surface is properly cleaned, then primed or sensitized, usually with stannous chloride. Taking care to avoid touching the prepared surface with the hands, it is then treated with a silver solution and a reducing agent, such as sugar, tartaric acid, glucose, rock candy, pyrogallic acid, Rochelle salt, and so on. After the silver is deposited the mirror is rinsed and dried at room temperature.

Modern mirrors are not merely articles for milady's boudoir. Mirrors for industrial and scientific purposes range from tiny reflectors for use in electrical instruments such as the galvanometer to huge mirrors for telescopes. Nor do mirrors use silver exclusively. Gold mirrors are occasionally used in optical reflectors, and for decorative and advertising purposes. Once they were supposed to possess magical powers. Small mirrors backed with ruthenium, the rare platinum-like metal, are used for medical and dental work despite their high cost. They have the great advantage of being unaffected by acids and alkalies. Platinum itself is occasionally used for backing mirrors.

Use is made of the mirror-forming reaction in the preparation of the parabolic reflectors used for motion picture projection in theaters. An accurate mold of the reflector is first made in glass, and silver is precipitated on its surface. The thickness of the metal film is then built up by electroplating a sufficient amount of copper onto the silver. To free the metal reflector from the glass mold, the whole is immersed in hot water, then in cold, alternating several times until the metal slips off. The silver surface is then plated with rhodium to make it non-tarnishing.

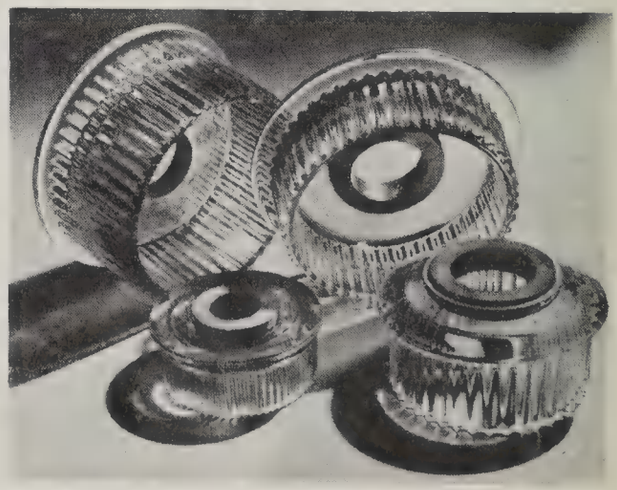
ELECTROPLATING — Glass, like other electrical non-conductors, may be electroplated by first applying a conducting film to the surface. Finely divided carbon is frequently used for this purpose. In this way a film of any metal that can be electrodeposited can be applied to a non-conductor. Vaporized metals may be deposited on the surface of a glass article also, forming a mirror-like composite. These metallic films find use in telescope and other reflectors as well as articles other than mirrors, as witness the familiar Dewar flask, the basis of the Thermos bottle, in which metallized surfaces serve for heat reflection; the vacuum tube of our radio sets, shielded by a conducting film; and gold-lettered windows and doors.

Metallized glass bottles and bottle closures are used as novelty containers, especially in the perfumery



Left: A metal drive quill is bonded into glass impeller for a centrifugal pump

Photos courtesy Corning Glass Works



Right: Lead bushings in godet wheels are used to secure perfect fit on spindles in rayon mills

and cosmetic industries. Gold lettering, when applied to glazing in place, is accomplished by the use of metallic gold leaf and an adhesive. Recently, vaporization of magnesium has been tried for the production of Dewar flasks. Nickel mirrors have also been prepared from nickel carbonyl compounds.

The incandescent lamp and the vacuum tube have presented their own problems in glass-metal collaboration. Early incandescent lamps were evacuated instead of being nitrogen-filled, and considerable difficulty arose in carrying the conductors through the glass envelope. The greater expansion of the metal wire caused gradual leakage at this point. It was solved by sealing tiny bits of platinum wire into the glass, joining to baser metal inside and outside the envelope. Platinum was selected because its coefficient of expansion is very nearly that of glass. Cheaper alloys of low expansion have since replaced the noble metal.



Courtesy Corning Glass Works

SOLDERING—For certain types of vacuum tubes, the heart of the modern science of electronics, metal diaphragms must be placed in the walls of the glass envelopes. Metal must be fastened to glass so solidly that a hermetic seal is maintained even under the changing temperatures of the tube in operation, and with an extremely high vacuum in the tube. In those tubes intended for war use, as well as in many types for industry, vibration and shock are added service hazards. Metallizing techniques have been developed that permit soldering metal parts to the prepared area, the resulting bond being so secure that the glass itself will break before the bond fails.

The ability to deposit metal films on glass is valuable in other electrical applications also. Glass tubes with metallized bands serve as resistors in electrical applications for which such special requirements as corrosion resistance must be met. Similar glass tubes with metal deposited as a coil may be used in transformers, obviating the use of wire coils. Wherever needed, this method makes it possible to plate conducting channels into one of electricity's best insulators, glass, conductor and insulator becoming one unit material. Silver films on glass form radio condensers of special types.

Electrodeposition of metals on glass is sometimes used in the chemical industry, where thermometers must withstand hard service. When temperature readings are required in a time interval so short as to preclude armoring the thermometer bulb, deposition of a heavy coat of corrosion-resistant metal over the bulb has proved effective in reducing breakage.

Metal ornamentation of glass is a procedure of long standing. Gold and platinum bands are applied to glass tumblers by means of metal paints, consisting of the metal or its compounds mixed with an essential oil. The paint is applied to the surface of the article, then fused in. For large-scale production the entire operation is done mechanically, plain tumblers being fed into the machine by an attendant and removed with metallic bands applied and fused in.

For various mechanical purposes it is desirable to have metal lugs firmly attached to glass. Platinum or silver films, electrodeposited or painted and fused, form a basis for soldering such attachments. In high-vacuum work in the chemical industries, glass tubing must sometimes be hermetically sealed into metal forms. The same metallized areas and soldering solve this difficulty also.

WIRE-DRAWING—Not all glass-metal combinations consist of metal films on glass, however. A recent development in the wire-drawing industry illustrates an entirely different type of use. A difficulty in drawing wires of steel or stainless steel is the need for feeding thoroughly annealed metal into the wire dies, in which it must undergo severe cold-working. The metal must be free of surface oxides also, as these would be forced into the wire during the drawing operation. A means of annealing the wire has been found in which a bath of molten glass is used. The wire is fed into the bath, which has a temperature of 1900 to 2300 degrees, Fahrenheit, according to the type of steel, held there for from 10 seconds to three minutes for annealing, then withdrawn from the opposite side of the bath and coiled. A coating of glass adheres to the wire, preventing contact with air during the cooling period. As cooling progresses below the temperature range at which rapid oxidation occurs, the glass shatters and separates from the wire, taking any oxides with it. The glass may be collected and re-used.

The same process may be used for narrow steel strip and its use for sheet steel and bar stock has been predicted. By a slight modification of the process, in which molten glass is sprayed onto the metal by spray

Left: After glass is metallized, metal parts can be attached with a soldering iron

Right: Glass linings protect medicinals — in this case, a glandular concentrate



Courtesy Pfaudler Company

guns, the method has been adapted to annealing rods.

To reduce corrosion of stainless steel wire during annealing, it had been standard practice to coat it with lead. The lead was difficult to remove completely. Glass processing was found to be not only satisfactory in itself, but also to provide a means of removing the lead coating when desired.

Chemical equipment frequently makes use of the corrosion resistance of glass, but finds the strength and freedom from breakage of steel desirable also. For large vessels not easily fabricated from glass alone, steel may be formed or partially formed to the required shape and lined with glass which is fused to the steel surface. By present techniques it is possible to weld such steel-glass vessels to similarly lined pipe, and so to form the equipment into a single unit. Apparatus of this type finds use especially in the preparation of dyes, drugs, and medicinals, including vaccines and penicillin, which must be free from even minute particles of contaminating material.

Godet wheels, used in the rayon industry, may be economically formed of glass, and here the corrosion resistance of glass is of great importance also. However, the glass wheel must be mounted on a steel spindle for operating. It has been found possible to cast a lead bushing into the glass wheel, and to machine this bushing to fit the steel spindle accurately, so that the wheel functions with runout held to very close limits.

The chemical industry also appreciates the resistance to chemical attack offered by glass to the extent of constructing centrifugal pumps of this material. Here again there arose the problem of attaching the glass impeller to the metal drive quill. Use was made of those low-melting bismuth alloys that have been adapted to so many new purposes within the past few years. The steel quill was inserted into the glass impeller, and locked in place by pouring Wood's metal around it. Final finishing of the intricate glass part then took place.

An even simpler method of permanent attachment of glass and metal is used in the case of a glass float. The float must be attached to a metal rod to actuate a liquid shut-off valve to a tank. In fusing the end of the glass float to seal it, a slight flange is formed in the glass. A threaded brass spud is then spun over the flange, and the rod screwed into the spud.

METAL INSERTS—It is frequently necessary to insert a small metal part, often threaded, in a glass form in order to attach other metal parts. Because of the difference in expansion of glass and metal when heated, it has heretofore been almost impossible to make these insertions at the time of forming the molten glass. A new process, called multiforming, offers a solution of the insert problem. Here the glass is powdered, then formed in a mold with the insert in place, and finally sintered at a relatively moderate temperature.

Metallic lead has been quite generally used for shielding operators from the harmful radiations from X-ray equipment, but it is frequently desirable to view the work during the period of radiation. A type of glass containing 61 percent lead has been produced, offering X-ray protection equivalent to about one third its thickness of metallic lead. It is about twice as heavy as ordinary glass.

Applications in which glass and metals are close collaborators without becoming a unit material are exceedingly diverse. Several recent developments are the use of metal-supported glass fibers as filter units for air conditioning; steel-framed glass bricks for construction; glass fiber insulation of copper wire and other electrical conductors in applications where temperatures make combustible insulation undesirable; watchmen's booths of armor steel and bullet-proof glass; and metal-supported glass fibers for heat insulation in domestic ranges, aircraft, and pipe lagging.

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ALUMINUM BEARINGS

Stand Up Well Under Hard Service

A SIGNIFICANT development in the bearings field is the growing use of aluminum-alloy bearings for heavy-duty service. Alloyed with tin, and running against hardened shafts or journals, the aluminum bearings are successfully withstanding high loads in truck, tractor, and automobile engines.

Among the most valuable properties they possess for this service is their high heat conductivity, which keeps surface temperatures down, and their good frictional characteristics. Lightness, too, is often an important mechanical advantage.

The aluminum bearings are made as solid bearings (rather than as linings)—usually cast. Considerable interest has recently been shown in aluminum bearings made from metal powders, which possess the additional advantages of lighter weight and greater oil-carrying ability because of their characteristic porosity.

PREPLATED METALS

Save Materials and Speed Production

JUST taking hold at the war's outbreak, the idea of using "preplated" metals for various corrosion-resisting products has found wide acceptance in the past few years.

Instead of the conventional practice of buying strip steel, stamping or punching out the required parts, and then electroplating or lacquering them individually, the manufacturer may now purchase sheets or coils of steel or other base metal already plated in bright chromium, nickel, copper or brass. The preplated strip may then be stamped or formed, the plate being such as to withstand any but the most severe operations without flaking or peeling.

Preplated metals are reported to have saved tons of critical corrosion-resistant alloys and much production time during the war period.

BLACKENED STAINLESS

Developed for War; Has Peace-Time Possibilities

DEVELOPED originally to provide a corrosion-resistant metal that would not reflect light when used in gun parts, a new group of blackened stainless steels are now being studied by post-war-planning engineers for possible peace-time uses.

The process, patented by Rustless Iron and Steel Corporation, may be applied to straight chromium or nickel-chromium stainless steels and consists of immersing the parts to be blackened in a molten bath of sodium (or other) dichromate at about 750 degrees, Fahrenheit. An adherent, ductile, abrasion-resistant, 0.00001-inch-thick black coating results that does not harm the corrosion-resistance of the steel.

Used in the Army's Garand rifle and in the Navy's Bludworth depth sounder, the blackened stainless steel is believed to have interesting possibilities for such peace-time products as bolts, screws, molding, trim, motion picture projectors, photographic equipment, surgical instruments, jewelry, and other black parts requiring corrosion and heat resistance, stratospheric cold-toughness, non-magnetic properties, and high strength-weight ratio.

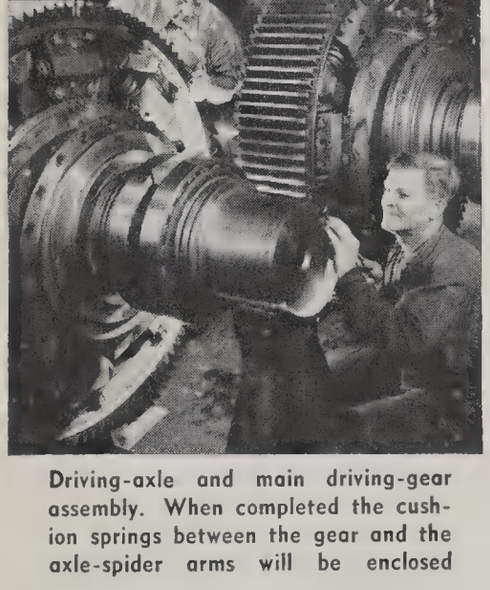
Turbines On Rails

At Operating Speeds, the First Locomotive In America to be Driven by a Steam Turbine Geared Directly to the Driving Wheels Compares Favorably With the Most Economical Reciprocating Units. A New Era of Rail Power May be in the Making as this Locomotive Accumulates Mileage. The Unique Gears are Being Carefully Watched by Engineers

FAMILIAR steam cylinders, crossheads, and main driving rods of the conventional locomotive are missing on the Pennsylvania's No. 6200, and a large covered pipe extends alongside the boiler on the right side of the locomotive. These are the superficial earmarks of the first gear-drive steam-turbine locomotive in America.

Structurally, this locomotive follows well-established lines. The usual cylinder castings have been replaced by a steam-turbine driving unit, which consists of forward and reverse turbines and speed-reduction gears which connect the turbines to the Number 2 and 3 pairs of driving wheels. The large pipe on the right side of the boiler carries the exhaust steam from the forward turbine casing to the exhaust nozzle in the smokebox. This creates the draft just as in the reciprocating steam locomotive, except that the steam and gases issue from the stack with a steady blow, unaccented by the customary sharp beats of the exhaust of the reciprocating locomotive.

The Pennsylvania Railroad became interested in 1937 in improving the performance of steam passenger locomotives by the use of a geared steam turbine instead of the customary reciprocating steam engines. In the development of the design, engineers of the Baldwin Locomotive Works worked with those of the railroad and of Westinghouse Electric Corporation. The drawings were ready late in 1941. Wartime difficulties in getting materials required a number of changes, but the locomotive was finally delivered to the railroad in September, 1944.

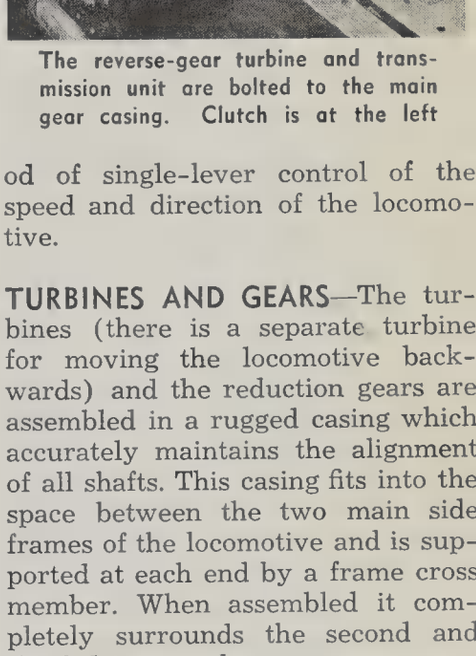


Driving-axle and main driving-gear assembly. When completed the cushion springs between the gear and the axle-spider arms will be enclosed

The locomotive is designed to deliver 6900 turbine shaft horsepower in forward motion and is intended for high-speed freight or passenger service. The length and weight of modern passenger trains have grown so great, and the speeds demanded of freight trains have become so high, that the same kind of locomotive has become suitable for both services.

Because of the greater weight required by the substitution of certain non-critical materials for the stronger or lighter materials originally specified, it became necessary to replace the four-wheel leading and trailing trucks with six-wheel trucks and the locomotive is designated as a 6-8-6 type (six-wheel leading truck, eight-coupled driving wheels, and a six-wheel trailing truck). The boiler carries a working steam pressure of 310 pounds. The pressure at the steam turbine inlet is 285 pounds per square inch gage, and steam is delivered from the superheater to the turbine at temperatures up to 750 degrees, Fahrenheit.

Three features of this locomotive are of outstanding interest. These are the turbine and reduction-gear unit, the unique adaptation of the quill drive so well established on electric locomotives, and the method of single-lever control of the speed and direction of the locomotive.



The reverse-gear turbine and transmission unit are bolted to the main gear casing. Clutch is at the left

TURBINES AND GEARS—The turbines (there is a separate turbine for moving the locomotive backwards) and the reduction gears are assembled in a rugged casing which accurately maintains the alignment of all shafts. This casing fits into the space between the two main side frames of the locomotive and is supported at each end by a frame cross member. When assembled it completely surrounds the second and third driving axles.

The forward turbine comprises one Curtiss two-row stage and five single-row reaction stages. Steam is admitted through four nozzle groups, each fed by a three-inch steam pipe. A steam header and throttle valve are located at the top of the smokebox behind the smoke stack. Steam from the superheater units is admitted to the nozzle pipes by four cam-operated valves which are opened in succession and which can be moved in small increments. Close regulation of speed and power is thus attained.

At a locomotive speed of 100 miles

an hour the turbine shaft rotates at approximately 9000 revolutions per minute. The double-helical high-speed pinions are on a hollow shaft. The drive shaft extends through the hollow shaft and is connected to it at the opposite side of the unit.

The reverse turbine is a single Curtiss double-row stage which is mounted on an extension of the reverse pinion shaft. This double-helical pinion drives a double-helical reverse gear which, in turn, drives the main pinion through a dog clutch on the end of the main pinion shaft. The forward turbine is permanently connected to the gears and rotates when the locomotive moves backward.

Steam is admitted to nozzles in the base and cover of the reverse-turbine cylinder from a single inlet pipe, which is supplied through a cam-operated valve similar to those which supply the forward-motion turbine. The maximum speed at which the locomotive should operate backward is 22 miles an hour. At this speed the reverse turbine rotates at approximately 8300 revolutions per minute and develops 1500 shaft horsepower.

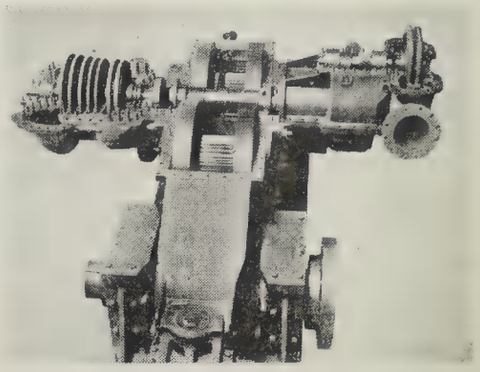
The main double-helical high-speed pinion meshes with two pairs of double helical gears. Between the double helicals are the single spur gears, each of which, in turn, meshes with one of the large axle drive gears.

Several features in this unit are unusual. The tooth loads and the surface hardness of the contact surfaces of the helical pinions and gears are more than double the values customarily used. Again, great care was exercised in the design to prevent any possible locomotive frame distortion from being transmitted through the gear case to the heavily loaded gears and their bearings. To accomplish this the attachment of the gear case on the locomotive frames is through a three-point suspension. At one end of the case is a wide horizontal tongue which fits into and is secured to the jaws of a horizontal bracket. The bracket is secured to the frame cross-member. Bosses both top and bottom along the sides of the tongue fit snugly between the jaws of the bracket and provide two points of suspension which fix the vertical alinement of the gear case between the frames. The position of the case is stabilized at this end by rubber compression blocks between the sides of the gear case and the bottom rails of the frames.

Instead of a jaw-and-tongue attachment, the bracket which supports the other end of the gear case on the locomotive frames has a longitudinal trunion which fits in a bearing in the end of the case. It will be seen that the gear case is thus completely relieved of stresses which rigid connections would transmit to it from slight torsional or lateral bending strains in the frames.

QUILL DRIVE—Since the gear case is attached to and alined with the locomotive frames, and the frames are supported on the driving boxes by springs and equalizers, it is evident that the alinement of the driving axles varies through a considerable range from a parallel and concentric relationship to the axis of the driving gears. The quill drive was developed to meet this situation and has been used on a large number of electric locomotives. In these locomotives the frames and journal boxes are usually outside the wheels; the driving motors, which occupy the space between the driving wheels, are rigidly attached to the frames. The rotation of the main gears is transmitted directly to the driving wheels by spring-cushion cups on lateral projections on the gear which extend between and bear against the spokes of the wheels. The driving axles pass through the hollow shafts of the main gears with ample clearance to permit them to adjust themselves for the necessary changes in relative alinement.

The same principle is employed on the steam-turbine locomotive. But because the driving wheels are outside the frames, the drive comprises a single low-speed spur gear for each of the two axles. Each gear is located on the longitudinal center of the frame and around the axle



Transmission unit with covers removed from main gear casing, forward turbine (left), and reverse turbine (right). Spur gears between the helical gears mesh with the axle gear

which it drives through a single spider pressed on the axle.

The hardened faces at the ends of the radial arms of the spider bear against spring-cushioned cups which slide in sockets on the inside of the low-speed spur-gear rim. The quill constitutes seats for roller bearings, one on each side of the gear center. The gear is alined by the outer housings of these bearings which are bolted in the sides of the gear case.

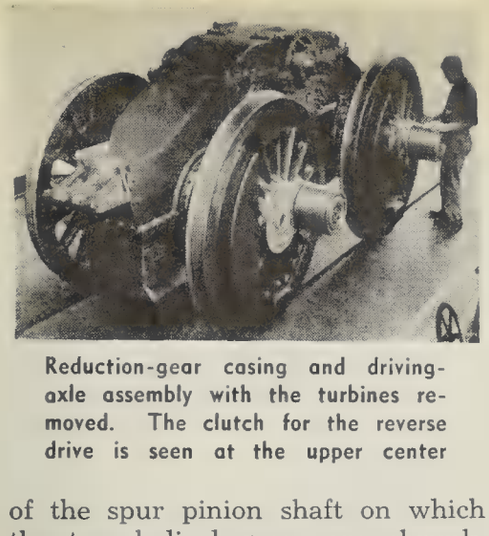
The spring cups serve to cushion the turbine and gearing from the shock of sudden changes in velocity of the locomotive, as well as to transmit rotation between two misalined systems. Enclosed in the reduction-gear case, they are lubricated by a bath of heavy oil.

Each gear delivers power to two pairs of driving wheels. To equalize the load on the two gears, all four pairs of drivers are connected by roller-bearing side rods.

The bearings of the high-speed pinion and the high-speed gear are lined with a tin-base babbitt. Because of the high linear velocity of the high-speed pinion shaft in its bearings, more than the usual amount of clearance is required in the bearings. The bearings of the high-speed gears are internal, being mounted in the hollow-bored ends



The first direct-driven steam-turbine locomotive built in the United States



Reduction-gear casing and driving-axle assembly with the turbines removed. The clutch for the reverse drive is seen at the upper center

of the spur pinion shaft on which the two helical gears are shrunk. The bearings rotate with the gears on fixed steel trunions secured to the sides of the gear case.

SINGLE-LEVER CONTROL — A single lever at the right side of the cab and immediately in front of the engineman's seat controls both the speed and direction of the locomotive. The lever moves forward and backward in a slotted quadrant. The slots are parallel but not in line with each other and at the central position of the lever in the middle of the quadrant it can be crossed over from one slot to the other. The central position of the lever is the "off" position. Moving it into the forward slot controls the flow of steam to the forward turbine. The flow of steam and the speed of the locomotive are increased as the forward movement of the lever is increased. Moving the lever back towards the center of the quadrant reduces the steam flow and at the center stops it entirely. With the locomotive at rest, crossing the lever over and moving it backward in the rear slot first engages the clutch between the backward turbine reduction gear and the end of the double-helical high-speed pinion shaft in the main gear case and then admits steam to the backward turbine. Until the clutch is engaged, steam cannot be admitted to the turbine.

These functions are performed by a so-called "pneudyne" control system furnished by the Westinghouse Air Brake Company. The pneudynes are pneumatic cylinders controlled by air valves. The one for the forward motion is located on the engineman's side of the locomotive and rotates the throttle-valve cam shaft through a rack and pinion. The reverse pneudyne is located on the fireman's side of the engine and is connected by lever to the reverse-throttle cam shaft. The system includes over-speed and low-lubricating-oil-pressure protection valves. These operate to close either throttle by exhausting the control air to the atmosphere if the locomotive speed exceeds 110 miles an hour forward and 25 miles an hour backward, or if the oil pressure falls below five pounds per square inch.

The clutch which transmits power from the reverse turbine to the main gear case is hydraulically actuated. Engagement or disengagement of the clutch when the locomotive is moving is prevented by a "zero speed" interlock in the pneumatic-control circuit.

BOILER—The boiler is of large capacity with a total combined evaporative and superheating surface of 7042 square feet and a large firebox and combustion chamber with a grate area of 120 square feet. Its largest outside diameter is 102 inches. One of the reasons which makes the large boiler possible is the small diameter of the driving wheels. Because of the desirability of keeping piston speeds within certain limits, the diameter of the driving wheels of reciprocating steam locomotives intended for high-speed service are usually not less than 78 inches and are frequently 80 inches. Because of the absence of pistons, the uniform torque of the turbine, and the complete rotating balance of the wheels and their side rods, there is no need to keep down the revolutions per minute of the turbine locomotive driving wheels. They are only 68 inches in diameter on No. 6200. This admits of a larger boiler without exceeding top clearances.

Reverse-gear casing with top removed

No. 6200 carries 260,000 pounds on the driving wheels and the total engine weight is 580,000 pounds. The tender, loaded with 18,000 gallons of water and 37½ tons of coal, weighs 449,400 pounds. The locomotive exerts a starting tractive force of 70,500 pounds forward and 65,000 pounds backward.

STEAM CONSUMPTION — Unlike the reciprocating steam locomotive, when steam is admitted to the steam turbine there is nothing to prevent it from blowing through to the exhaust even though the blades of the turbine rotor are stationary. In the reciprocating engine, it is only after movement of the pistons that steam can be exhausted from the cylinders. Hence, the steam turbine has a very high rate of steam consumption, measured in pounds per horsepower hour, in the starting and slow-speed range.

The unit consumption drops rapidly, however, and in the normal range of operating speeds the steam consumption of the turbines seems likely to compare favorably with the most economical reciprocating locomotives, if not better than some of them. In measuring this performance against the high efficiency of the steam turbine in central-station practice, it must be remembered that the turbines on locomotive No. 6200 operate at relatively low initial pressure and that they exhaust to the atmosphere—that is, they operate non-condensing.

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TURBINE LOCOMOTIVES

Three More Types Coming Along

PARTICIPATING in a co-operative development of a steam-turbine-electric locomotive which has been under way since November, 1944, are General Electric Company, Babcock and Wilcox Company, and nine railroads. This locomotive will burn pulverized coal, will generate steam at 650 pounds per square inch, and will develop 6900 shaft horsepower in a non-condensing turbine. By the use of pulverized fuel the sponsors anticipate the production of a horsepower-hour at the drawbar with one third less fuel than required by the most efficient conventional steam locomotives.

Turbine-driven steam locomotives departing from the conventional locomotive form have been proposed by the Pennsylvania and the Chesapeake & Ohio Railroad. In general arrangement the two locomotives will look somewhat alike. The one for the Pennsylvania, however, will be driven by two geared steam turbines developing a total of 9000 horsepower. That for the C. & O. will be driven by a 6000-horsepower steam turbine through electric generators and motors. The basic designs have been completed by the Baldwin Locomotive Works. The electrical equipment will be built by the Westinghouse Electric Corporation.

Solarization

Glass in Ultra-Violet Lamps Tends to Deteriorate or Solarize as the Lamps are Used. A New Glass Has Now Been Developed which Transmits Ultra-Violet Radiation Freely but Does Not Solarize. How it Was Determined that Alkali in Glass is the Cause of Solarization

By DR. HARVEY C. RENTSCHLER
Director of Research, Lamp Division
Westinghouse Electric Corporation, Bloomfield, New Jersey

THE EFFICIENCY of an ultra-violet lamp is dependent upon the ability of the glass to transmit short-wave ultra-violet radiation; in many commercial lamps the life of the electrode governs the life of the lamp. Together, then, the glass and the electrode govern the overall useful production of ultra-violet radiation.

There are now available bactericidal ultra-violet lamps having electrodes of indefinite life, but full advantage of these long-lived electrodes could not be taken because of the deterioration or "solarization" of the glass which resulted in a decrease in its ultra-violet transmission efficiency.

Recently, however, there has been introduced a new glass which practically solves this problem. Manufactured by the Corning Glass Works under the trademark Vycor, it possesses the unprecedented characteristics of being able to transmit almost perfectly all ultra-violet radiation of wavelengths longer than about 2500 angstrom units and shows very little, if any, solarization upon exposure to short-wave radiation. At the same time, this glass transmits very little radiation below 2000 angstroms. This factor eliminates the production of excessive quantities of ozone by these short wavelengths, which is one of the objections to using quartz for bactericidal lamps.

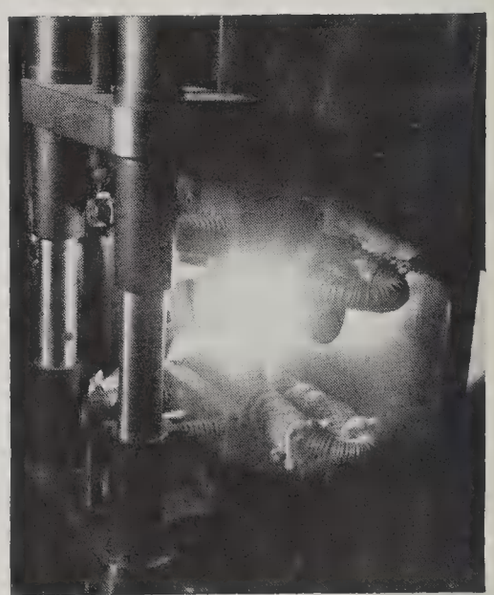
Vycor is a borosilicate glass containing about 96 percent silica. In some respects, it is similar to quartz. It has an expansion coefficient of of 7.5×10^{-7}, which makes it necessary to join several types of glass to form a graded seal so that a glass having an expansion coefficient close to that of the metal electrode leads can be used to produce a vacuum-tight joint at the point where the leads are sealed into the lamp.

Zschimmer (*Physik, Zeitsch.* 8, p. 611-1907) pointed out that boric oxide, B_2O_3, and silica, SiO_2, in their pure state are very transparent even below 2000 angstroms, that the addition of metallic oxides lessens the transparency, that sodium oxide, Na_2O, acts more strongly than potassium oxide, K_2O, and that lead oxide, PbO, absorbs very strongly.

METAL OXIDES—The absence of transmission of ultra-violet in ordinary window glass is generally attributed to the presence of metallic oxides in the glass. In addition to the alkali oxides mentioned above, all glasses contain small traces of iron, magnesium, aluminum, manganese, and titanium. Solarization has been commonly attributed to the action of the ultra-violet in converting the metallic oxides from one form to another.

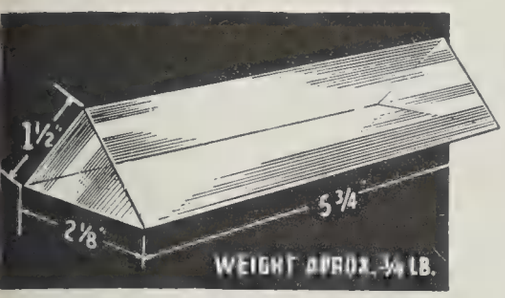
The fact that Vycor and quartz show only negligible solarization as compared with the solarization associated with all the glasses that



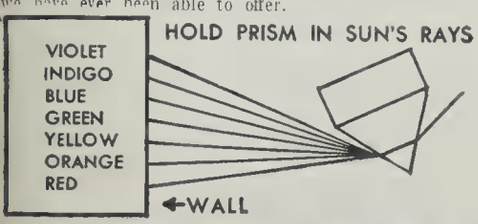


Dr. Rentschler, the author of the accompanying article, inserts (left) a carbon cup containing powdered glass into the lower jaw of the spectroscope's arc stand. It was in the course of such work that the cause of solarization of glass by ultra-violet rays was determined. Right: A close-up of a burning sample in the carbon electrode after igniting

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3001-S	Lens Surface Prism. Each	2.00
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3021-S	Amici Roof Prism (3rd Grade). Each	.25
4009-S	Heat Absorbing Glass 4" x 5". Each	.35
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2020-S	40 mm. Neg. Lens, Cross Lines. Each	.25
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6081-S*	35	55	Uncemented	70c
6082-S*	37	57	Uncemented	70c
6084-S*	41	66	Uncemented	70c
6085-S	45	135	Uncemented	$1.00
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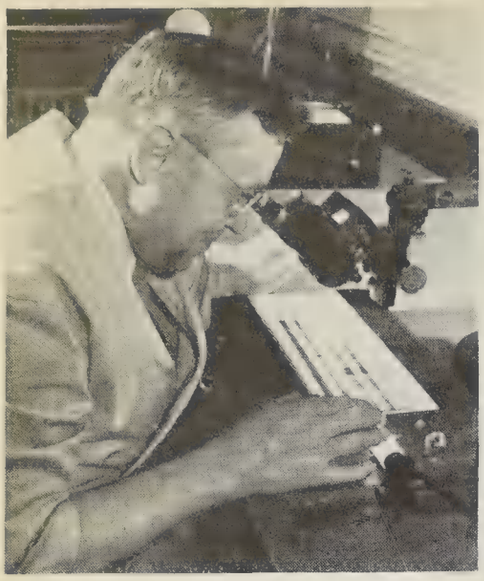
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Examining spectra of glass samples

have been used in bactericidal lamps suggested that a spectroscopic analysis be made of the different glasses as well as of Vycor and quartz in an effort to detect traces of the impurities which might be responsible for causing the solarization.

In making this analysis, the material to be tested—Vycor, quartz, or glass—was ground into a fine powder in an agate mortar. A mixture of equal amounts of the powder and of sucrose carbon was placed in a hollow spectroscopic carbon electrode. An arc between this electrode and a second carbon, focused on the slit of a large spectrometer, vaporized the material contained in the cup and the resulting spectrum was photographed in standard manner.

The spectral region used spans wavelengths from 550 to 3570 angstroms. All the metallic elements which are commonly present in glass have strong lines in this region of the spectrum and a comparison of the relative intensities of the lines of the metals in the different samples makes it possible to detect relative amounts of impurities in the various materials examined.

Spectrograms were taken for a number of glasses which have at one time or another been used in making Sterilamp bactericidal ultra-violet tubes. In addition to these, a number of samples of Vycor and of both fused quartz and quartz crystals were likewise tested.

The spectrograms of the glasses, the Vycor, and the quartz all showed the same amount of iron in all the samples tested, as nearly as can be judged from the intensities of the prominent lines on the spectrograms. Similarly, the spectrograms indicated the presence of the same amounts of magnesium, manganese, aluminum, calcium, and titanium in all the samples.

INFLUENCE OF ALKALI—The sodium doublet of wavelengths 3302.9 and 3302.3 angstroms was strong in the spectrograms of all the glasses but was completely absent in the spectrograms of all the Vycor and quartz samples, indicating that the presence of alkali in some form or another influences the solarization of the glasses and explaining the absence of this action with Vycor and quartz.

Another interesting observation about Vycor was made in an investigation carried out in addition to the spectroscopic analysis. It was found that the intensity of bactericidal radiation from a discharge through mercury vapor in Vycor, at one meter from the lamp, is more than that from a similar quartz lamp. This is because a negligible amount of ozone is generated by the Vycor lamp to absorb the 2537-angstrom radiation.

Although there are difficulties in processing Vycor into the lamps, this is more than compensated for by the longer life and more uniform output during the life of a Vycor lamp. This is highly important because, for most effective protection against contamination, it is essential that bactericidal ultra-violet radiation be continuous and of uniform intensity.

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FIRE-PROOF GASOLINE

Developed by Petroleum Industry

A GASOLINE with an octane rating equal to that of aviation fuel, but which is as safe to handle as ordinary kerosine, is one of the newest commercial developments in the petroleum industry. Experts claim that its use in airplanes will reduce the fire hazard by almost 90 percent. Recent tests of this new gasoline showed that it will not ignite even when splashed *directly over an open flame*. Tested under the same conditions, ordinary high-octane gasoline exploded and burned when splashed eight feet away from the open flame.

As long ago as 1931, Standard Oil Company (New Jersey) developed in the laboratory a gasoline which was practically free from the danger of accidental ignition under normal operating conditions, and which was at the same time equal or superior in octane rating to the best of the flammable types of gasoline in operating efficiency. (This work was first reported in Scientific American in March, 1932.)

Since that time the expansion of high-octane production facilities required by the war effort has made it necessary to construct large amounts of equipment which can now be used in the manufacture of this fire-proof gasoline.

The advantages of flame-proof gasoline in the safe operation of the giant Clippers carrying over 200 passengers, which Pan-American World Airways plans to operate in its post-war global service, is obvious. In the event of a forced landing on water, in which the fuel tanks are damaged, spilling several tons of gasoline on the water, the chances of an explosion and fire is minimized to the point of being almost negligible.

TENSION VIBRATOR

Supplies Data on Effects of Small Stresses

FATIGUE resistance testing, by vibration, of cords for tires, belting, and a long list of products in which fabrics play a leading role, as well as filaments for other purposes, is accomplished by a new cord tension vibrator which makes it possible to supplement information on tensile strength with new data on the ability of the cord, fabric, or filament to withstand repeated small stresses far below the tensile



Setting up the cord tension vibrator which includes provision for determining effects of heat on cord life

strength of the material. This has been designated by the broad term "fatigue resistance."

Effects of variation in temperature, yarn composition, and the fiber structure on the fatigue resistance of the material under test can be

accurately measured with the new Goodrich apparatus. Vibration rate can be changed and heat can be applied, to meet the needs of the particular test.

FM RECEIVER

Can be Built to Cover Wide Wave Band

EXPERIMENTS at the John Meck Industries, Inc., laboratory prove that it is possible to manufacture a frequency-modulation receiver which will operate not only in the 42-50 figure megocycle band but will also cover the proposed wide range of 84 to 102 megocycles now being considered by the Federal Communication Commission. The circuit is not a two-band set, and does not call for remodeling of an original set at the factory or by local service men. The wavelength bands are not changed by means of switches, but the circuit will not cover the unused band between 50 and 84 megocycles. However, if the Commission should change its mind and use the wavelength between 50 and 84 megocycles, a set could be built to cover the entire wavelength band.

GREENHOUSE LAMPS

Kill Plant Enemies And Provide Vitamins

SOIL sterilizing units and ultra-violet ray lamps are stamping out disease and stepping up production in greenhouses, according to electrical manufacturers.

The sterilizer heats the soil to a temperature of 160 to 180 degrees for 30 minutes, killing plant disease organisms as well as insects, fungi, and weeds.

At the same time, the plants receive an extra dash of vitamin D. Ultra-violet lamps supplement the sun in providing the vitamin supply. Infra-red lamps provide localized applications of heat.

Fluorescent lighting, duplicating daylight, is used to exhibit the flowers and plants in their natural colors.

TUNGSTEN

Broadens Its Use With New Technology

POWDER metallurgy utilizes various properties of metals to their best advantage and is a vital element in the production and control of millions of dollars worth of products each year in tungsten alone, Dr. Zay Jeffries recently said at the Powder Metallurgy Laboratory of Stevens Institute of Technology.

"A good example of the application of powder metallurgy is the cemented carbide," said Dr. Jeffries. "This material, which consists essentially of hard particles of tungsten carbide sintered with a small quantity of metallic cobalt, utilizes the tremendous hardness of the carbide for cutting and wear-resistant properties and it utilizes the toughness of cobalt to keep the hard, brittle tungsten carbide in one piece in service.

"Another example of the use of powder metallurgy is in the production of tungsten rod and filaments for the lamp, radio, electrical contact, and other industries. In this case, the melting point of tungsten is so high that no satisfactory method has ever been found of melting and casting it into ingots. The tungsten powder is produced by reducing tungsten oxide with hydrogen. The powder is pressed into briquets and heated by the passage of electric current to a temperature near 3200 degrees, Centigrade. At this temperature the briquet consolidates into an ingot which is then worked into rod and wire. Not only is powder metallurgy practically necessary for shaping tungsten but, by adding certain ingredients to the powder, vital grain size control is effected which, so far, has been found impossible to duplicate by the fusion method."



Frozen eggs in cans have been replaced by cellophane lined cartons — Photo courtesy, Du Pont, Wilmington, Delaware

Eggs in Cellophane . . .

War economy has changed packaging materially with cartons replacing heavy metals; cellophane liners for tin; revolutionary new moistureproof wraps replacing foils but net weights for the contents are still the same. Thirty pounds of frozen eggs are still thirty pounds whether they go into cellophane or tin for quick-freeze. Guesswork filling is just as unsatisfactory as ever no matter what type of container. Profitable liquid-fill operations are best handled by sound pre-determined fraction-ounce weighing. Gravity feeding to floor or low bench installed EXACT WEIGHT Scales gives you a simple, efficient operation for volume packaging with profitable results. Write for full details for your plant.

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Exact Weight Scales

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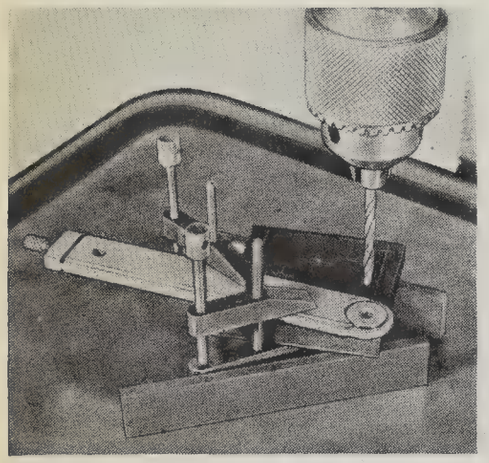
New Products and Processes

CENTER LOCATOR

Uses Magnifying Glass For Greater Accuracy

MACHINISTS can speed up many operations in constructing tools, dies, molds, and patterns and at the same time obtain a fine degree of accuracy with the new optical center locator illustrated.

After the work has been laid out, the compound magnifier is clamped into the holding fixture and it is then slowly moved over the intersecting layout lines. Once the reference circle, which is etched on the sight glass, is exactly centered over the layout lines, the holding fixture is clamped to the work. The magnifier is then removed from the holding fixture and the correct



Drilling holes where you want them and not a few thousandths off center is assured by using this new device

size drill bushing is substituted. All drill bushings are hardened, then precision ground to be concentric.

The outside diameter of each drill bushing is exactly the same as the diameter of the lower magnifier ring which contains the sight glass on which the reference circle is etched. When a drill bushing is substituted for the magnifier in the holding fixture the center of the bushing is precisely located over the intersecting layout lines. Holes can easily be located and drilled with an accuracy of .001 inch. The work is usually placed on parallel bars to facilitate alinement of the bushing and the drill.

STEAM CLEANING

Expedited by Powerful Emulsifier

A HEAVY-DUTY steam cleaning compound, marketed under the name of Steam-Off, has proved to be particularly effective in the removal of the heaviest and most stubborn grease and dirt from iron and steel surfaces, concrete, brick, and structural materials, gasoline and Diesel engines, steam shovels, tractors, locomotives, and road building machinery.

Extremely powerful in its penetrating and emulsifying actions, this new Turco compound combines a high degree of quick cleaning energy with the maximum ability to soften water, which results in producing reliably clean work, rinsing freely, and leaving no film, curds, water spots, or streaks. It was designed to function without the loss of cleaning power in the hardest water, and to prevent the depositing of hard water scale, which clogs coils and other vital parts of steam cleaning machinery.

Used as a stronger solution, Turco Steam-Off has the ability to remove unwanted painted surfaces as it cleans, making it a particularly effective product for complete overhaul or reclamation projects.

PLASTICS YARN

Is Adaptable to Many Post-War Industrial Uses

A PLASTICS yarn has recently been developed which promises to make long-wearing sheer hosiery and fill many other uses in the post-war world. Sheer dress materials that are resistant to perspiration and mild acids; auto seat covers immune to grease, oil, and alcohol; drapes and furniture upholstery that are fire-retardent and self-extinguishing are all possible with the new Plexon yarn, a product of Freydberg Bros.-Strauss, Inc.

The new yarn is a combination of existing fibers such as cotton, silk, rayon, or Fiberglas with plastic solutions, making possible an almost infinite variety of physical properties. Seventeen different plastics formulas are available and can be used, depending upon the final requirements of the finished yarn. It can be made either fine or heavy, stiff or soft, smooth or rough, transparent, translucent, or opaque, and with bright or mat finish. The threads can be made round, oval, triangular, or square. The present color range consists of 120 shades, and these can be increased at will. Plexon can be power loomed, woven, twisted, braided, or knitted.

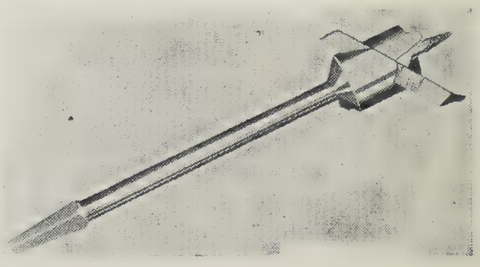


Just a few of the hundreds of post-war articles which can be made by combining a new plastics and standard fibers

EXPANSIVE BIT

Has Sharp Point, Long Life

DESIGNED on an entirely new principle, an expansive bit created specifically for use in hand braces to cut holes in



Another handy bit for your tool kit

wood is announced by Bruno Tools. The center lip which cuts away the core at the center of the hole extends back to form a clamp which firmly holds the adjustable blade at the diameter set. The clamp is locked tight by means of a screw. Once locked in the positive wedge-lock groove the cutter remains securely in place.

An improved diamond shaped screw point gives longer life by lessening the chance of breakage. The lead screw is threaded finer than is usual for this type of tool. This feature helps pull the bit through the wood, requiring only light pressure to cut quickly and cleanly because the lead screw is continuously and firmly engaged while the adjustable blade is cutting. The threads differ on models available to correspond to the capacity of each tool. Thus, regardless of the diameter of the hole being cut, whether through thin material or thick, clean, true holes are cut with a minimum of effort. A large open throat keeps the cutters clean of chips.

WELDED SEAMS

Produced Rapidly by Automatic Machine

DUPLEX resistance seam welders, designed for simultaneous seam welding of two or more seams on one surface, for rapid fabrication of sheet metal ammunition boxes, offer definite economies for many similar types of fabricating operations.

The machines, made available by Progressive Welder Company in a wide range of capacities and sizes, are air operated and fully automatic. A duplex head on the machine accommodates either two or four welding wheels. All

wheels are free rotating. They are driven by contact with the moving work under welding pressure.

The work itself is carried on a work table mounted on horizontal slide rails. The top of the work holding fixture is formed by a flat copper plate which provides the lower path for the welding current between the welding wheels. Welding wheels, lower electrode, and welding transformer are all water cooled. A deep coolant trough is integral with the moving work table.

The entire assembly—bearing the work to be welded—moves in and out of the machine as the welding operation proceeds. Operation of the moveable table is accomplished by an air cylinder connected with hydraulic cylinders acting as dash pots to insure uniformly smooth table travel.

Machine operation is completely automatic. The operator loads the rotary fixture and depresses the foot switch. The table moves forward into the machine; the welding heads depress simultaneously at the proper point; and the outside pair of welding wheels make two parallel seam welds of predetermined length. The head rises while the rotary table indexes—rotating through 90 degrees—and then the inside wheels weld on the "out" stroke of the table. Thus, two separate pairs of seam welds—each pair at right angles to the other—may be produced. The fixture indexes a second time back through 90 degrees at the completion of the "out" stroke and the table stops at the loading position.

DOVETAILS

Produced Automatically in "Wood-Welding" Process

NORMAL dimensional limitations of lumber in the prefabrication of things made of wood—from ironing boards to houses—are eliminated in a new Muskegon Machine Company, Inc., set-up which produces new results by the combination of various known principles, applied to automatic mass prefabrication. With the process, panels, ranging from ½ to 3 inches thick, from 10 inches to 16 feet in length, and of practically any width desired, can be made "in one piece," automatically, on a single machine, using only three men per machine—two to feed untrimmed lumber of any size into the two ends of the machine, one to remove the jointed assembly from the center.

The machine used in the process is an evolution of the well-known Linderman machine, used for over a quarter century to eliminate waste in the lumber industry. Prime characteristic of this machine is that it "welds" wood together in such a manner that a wider piece made from two narrow pieces is at least as strong and frequently stronger than would be a single piece of the same width. This is accomplished by use of a double-tapered dovetail joint with one or more dovetails for the pieces, supplemented by an automatic gluing process. The joint locks the wood sections together solidly and the glue "fuses" the assembly, the glue being forced into the cells of the wood at the joint to form a "welded" bond even stronger than solid wood.

In using the new Linderman automatic fabricating process to produce solid panels for such items as bookcases, ironing boards, table and desk tops, doors, house construction accessories, caskets and boxes of all kinds, and so on, square-edged lumber or even lumber with the bark still on the edges may be employed. In operation, two pieces of lumber are fed in from opposite ends of the machine. As the lumber moves into the machine, cutters trim the board and cut tapered dovetail tongues and grooves in the edges. Boards moving in from one end are tongued. Boards from the other end are grooved. As the boards approach the center of the machine, the grooves and tongues are automatically covered with glue, using conical rollers (excess glue is removed with stationary "wipers" and returned to the reservoir). As the boards near the center of the machine, the tongue slides into the groove. As the movement continues, the fit becomes tighter and tighter, until the two boards are locked together.

If the finished panel is to be wider, the jointed boards are returned to one end of the machine, where they are again fed in to meet a single board coming from the opposite end. The panel then is three boards wide. This is repeated until the desired width is obtained. Finally, the assembled panel is ripped to the desired width. The edging is passed back into the machine



Ingenious New Technical Methods

Available Now to Industry in General

New Shankless Roll-Forged Drill is Faster, Tougher, More Economical

Developed by Ford for wartime uses—available now to industry in general. "More holes at less cost," is the claim for this ingenious new Shankless high speed drill—made in two parts—the drill itself, and a removable taper shank, known as the "drill driver." By this separation, costs to the user have been cut 20% to 30% under conventional taper-shank drills. In the conventional drill, the shank must be discarded when the point and flutes are worn out. Here, however, the drill driver is used throughout the lives of many drills. Shankless drills are roll-forged and twisted, unlike the machined manufacture of ordinary drills, for improved structure.

Principal advantages are (1) Lower first cost. (2) Greater hole production because of greater strength. (3) Reduced breakage with tough "shock-absorber" neck. (4) Greater length of usable flute. (5) Greater scrap recovery value of unused portion of drill.

Wartime advantages of Wrigley's Spearmint Gum show how this quality product, too, can help industry—once it again becomes available. In the meantime, no Wrigley's Spearmint Gum is being made; and none will be made, until conditions permit its manufacture in quality and quantity for everyone. That is why we ask you to "remember the Wrigley's Spearmint wrapper," as the symbol of top quality and flavor—*that will be back!*

You can get complete information from Republic Drill & Tool Co., 322 S. Green St., Chicago 7, Ill.



Shankless Drill and "Drill Driver"



Remember this wrapper

Z-78

for use in the next panel, making the operation continuous.

The process is not limited to fabricating panels by edge assembling. Lumber may also be assembled by running the stock on edge on to a flat piece, as for making molding stock. Likewise, lumber may be run across the grain for various uses such as flooring and cutting blocks.

GLASS MATS

Possess Desirable Characteristics For Many Industrial Uses

THIN, porous mats of bonded glass fibers have been successfully applied to a number of entirely new uses by the process and electrical industries.

In roll form, the Fiberglas mat is being employed as a material for wrapping underground oil, gas, and other pipe lines to protect them against corrosion and electrolytic action. The material can be wrapped around bitumen or coal-tar coated pipe, thus forming a continuous water-tight bond. The glass fibers are non-corrosive to metals. The material has negligible moisture pick-up. Its tensile strength is preserved through a wide range of temperatures and exposures to organic solvents and soil acids. The millions of fine intertwined glass fibers reinforce a larger amount of bitumen or coal-tar coating for a given thickness of wrapping, as compared to other carriers.

Primarily because of the high tensile strength and non-hygroscopic characteristics of the individual glass fibers, the Fiberglas mats are being employed as the base for a new plastics laminated material. Possessing a low and stable loss factor over a wide frequency range, the laminate greatly extends the field for plastics coil forms, condenser spacers, stand-off insulators, and so on, in radio, television, and other high-frequency electronic devices.

In building up the laminate, the Fiberglas mats are impregnated with a thermosetting aniline-formaldehyde resin, and are cured under high pressure. In addition to its low loss factor, the laminate possesses high strength, high temperature resistance, dimensional stability, resistance to fungus attack, and good machinability.

Fiberglas mat is also being employed as a base material for gaskets and sheet packing. The mat acts as a carrying medium for synthetic resins suitable for applications requiring resistance to heat, oil, and acids. Glass-base gaskets now being manufactured show high pressure resistance, good chemical durability, and little flow under flange pressure.

Made by Owens-Corning Fiberglas Corporation, Fiberglas mat is composed of fine glass fibers intertwined in random orientation and bonded together to form a thin, highly porous, felt-like material. The glass fibers have an average diameter of 0.0005 inch. Several types of binders—starch, gelatine, furfural, or phenolic—may be used, depending upon the requirements of the end use.

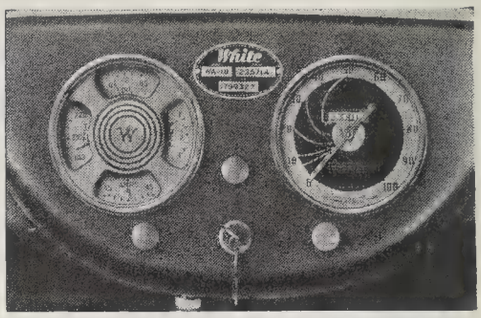
TRUCK OPERATION

Simplified by Instrument That Correlates Data

COMBINING the features of an ordinary speedometer with those of a tachometer and adding instructions governing various engine speeds, an "economy range finder" for trucks has been developed by the White Motor Company. With this device on the instrument panel the driver can increase the life of the engine by keeping it within its most efficient range of operation.

Even for the most experienced truck driver, gaging the engine speed and hence the proper time to shift gears is extremely difficult because of the varying ratios between engine speed and chassis speed (miles per hour). Grades encountered and the necessity of using various transmission gears to meet different conditions provide a constant change. Expecting a driver to pulse the engine speed without visual aids is like forecasting weather without benefit of scientific instruments.

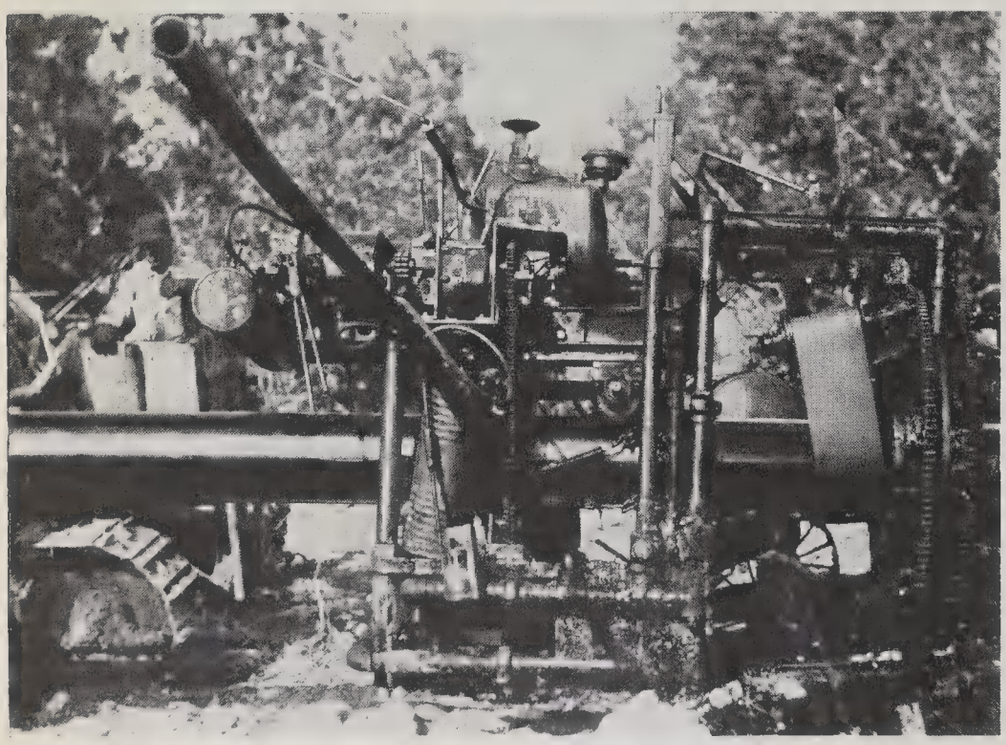
The economy range finder helps drivers in shifting gears, saving fuel, conserving trucks, and making schedules. Not only can they read the engine speed directly on the speedometer dial, but instructions are clear. A spiral



Instrument panel on a standard White truck showing how the "economy range finder" is built into speedometer dial

white line for each transmission gear is offered on the dial, and this is combined with a scale of engine speeds printed on the speedometer pointer. As the speedometer pointer moves around the dial, the edge of the pointer crosses the spiral white line for each gear. A white area on the pointer indicates the ideal operating range from 1700 to 2400 revolutions per minute, and at either end is a red area which indicates when the engine is operating outside the proper range. When the pointer reaches the outer end of the spiral line for any gear, the engine speed (noted in the red) will be 2800 revolutions per minute, at which the governor is usually set. As this recommended maximum is approached, the bearing loads, piston speeds, and vibrations are increased, thereby tending to shorten the life of the engine. Similarly, the red at the lower end of the pointer shows when the engine is laboring and in need of relief through shift to a lower gear. Such a shift will prevent strain and excessive wear by allowing the engine to operate more easily at a higher speed. As steeper grades slow the engine down, the greater load on bearings, pistons, and rings is much the same as when the maximum engine speed is reached or exceeded.

Thus the economy range finder is a simple but effective device to guide the driver in selecting the various transmission gears in which to operate under existing conditions. When the pointer crosses a white line at the outer end of the line, it indicates that the recommended maximum engine speed has been reached and that the driver should shift into the next higher gear. And when the pointer crosses a white line at the inner end it suggests a shift into the next lower gear.



Wrapping Fiberglas mat around an underground oil pipe line

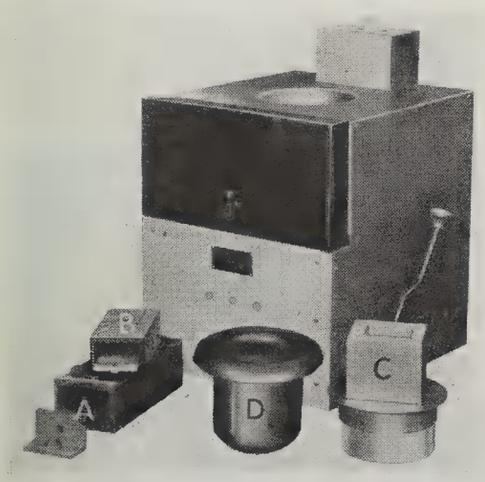
BENCH FURNACE

Offers Versatility for Shop or Laboratory

DESIGNED to provide for a wide variety of applications, a new "three-way" bench-type universal laboratory fur-

nace has been made available by Surface Combustion Corporation. The furnace combines three different types of furnaces in one casing. It may be used as a direct-fired oven unit at temperatures from 300 to 2400 degrees, Fahrenheit. For direct heating a muffle can be placed on the hearth. If an atmosphere is desired a diamond block can be used in the muffle. A removable plug built into the arch of the furnace provides a means of inserting a pot.

This laboratory furnace is ideal for small shops or laboratories where a wide variety of heat treatments in relatively small quantities of small parts must be performed. Such operations as annealing, carburizing, hardening, cyaniding, and tempering, with or without a furnace atmosphere, can be handled by the one furnace. It functions as a direct-fired oven, indirect heated muffle, gaseous atmosphere, salt or lead bath type and may also be used for melting soft and light metals.



The new bench-type laboratory furnace with accessory equipment including (A) muffle, (B) protective atmosphere equipment, (C) plug, and (D) pot

The furnace is equipped with three atmosphere-type gas burners, each of which can be independently controlled. The burners are arranged under the hearth to provide uniform and rapid heating throughout the heating chamber. A gas pressure regulator assures uniform control of burner operation. Manufactured or natural gas or butane or propane may be used.

WELDER'S SHOCK

Eliminated by Reducing Voltage

ARC WELDERS' apprehension of shock, and possibly subsequent nervous exhaustion, has been eliminated by a new safety panel invented and perfected by electrical engineers of Pullman-Standard Car Manufacturing Company. High open-circuit voltages of most welding equipment create a definite hazard to operators. The voltage encountered varies with different machines, but in general ranges from 85 to 110 volts. Since this voltage is ordinarily present at all times when not welding, physical contact of the operator from his welding electrode to grounded metal surfaces may have serious consequences.

When the welding contact is broken, the newly patented Pullman-Standard safety panel automatically reduces this open-circuit voltage of the electrode (which creates the welding arc) to a mere 24 volts. Accidents among welders are rare, but the new safety panel contributes greatly to the ease of mind of the welders. No longer must they be constantly on the alert while changing electrodes and the relief in nervous tension is quite noticeable when the new safety panel is used.

ARC-OXYGEN

Cuts Heavy Steel Quickly and Easily

ONE of the most valuable industrial tools to come out of World War II is the arc-oxygen electrode, which somewhat resembles an ordinary pea shooter. The electrode, information about which has until recently been restricted, combines the tremendous heat of the electric arc with the cutting effect of pure oxygen to cut steel many feet below the surface of the ocean.

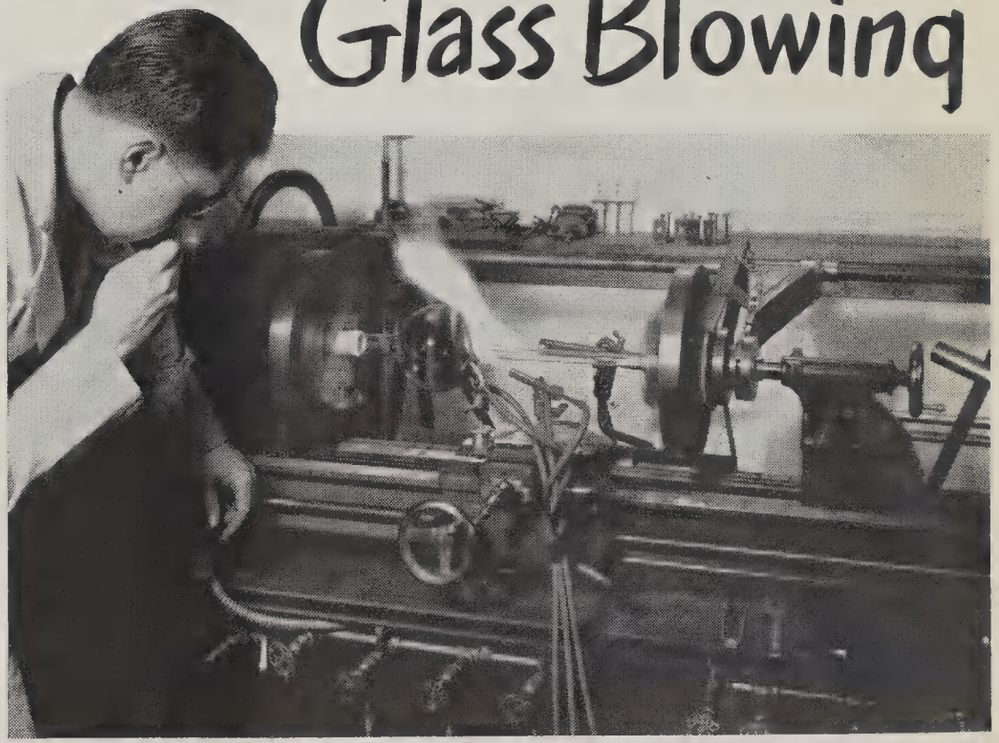
The development of the electrode by the Metal and Thermit Corporation in co-operation with the United States Navy has helped to make possible the tremendous speed with which invasion harbors have been cleared of sunken ships by Navy Salvage and Seabee Forces. Ragged shell and torpedo holes in war vessels afloat are also trimmed underwater and temporary patches welded, enabling stricken vessels to proceed to drydock for permanent repair.

The arc-oxygen process utilizes the heating properties of an arc flame, ranging from 6000 to 10,000 degrees, Fahrenheit, to kindle steel plates and beams much as coal is kindled by wood splinters. Into the molten steel thus produced, a jet of pure oxygen is introduced to cut cleanly through the steel.

The process allows divers easily and rapidly to cut large sections of steel, formerly impossible due to heavy diving gear, restricted movement, and poor visibility below the ocean's surface. So fast is the new steel-cutting elec-

Dr. E. A. Coomes, Professor of Electronics, University of Notre Dame, blowing glass on a South Bend Precision Lathe.

Glass Blowing



ON A SOUTH BEND LATHE

"Versatile" is apt description for South Bend Precision Lathes. This South Bend Lathe, provided with special fixtures by the school's own instrument shop, is used for blowing special glass equipment needed by the electronics research laboratory of the University of Notre Dame.

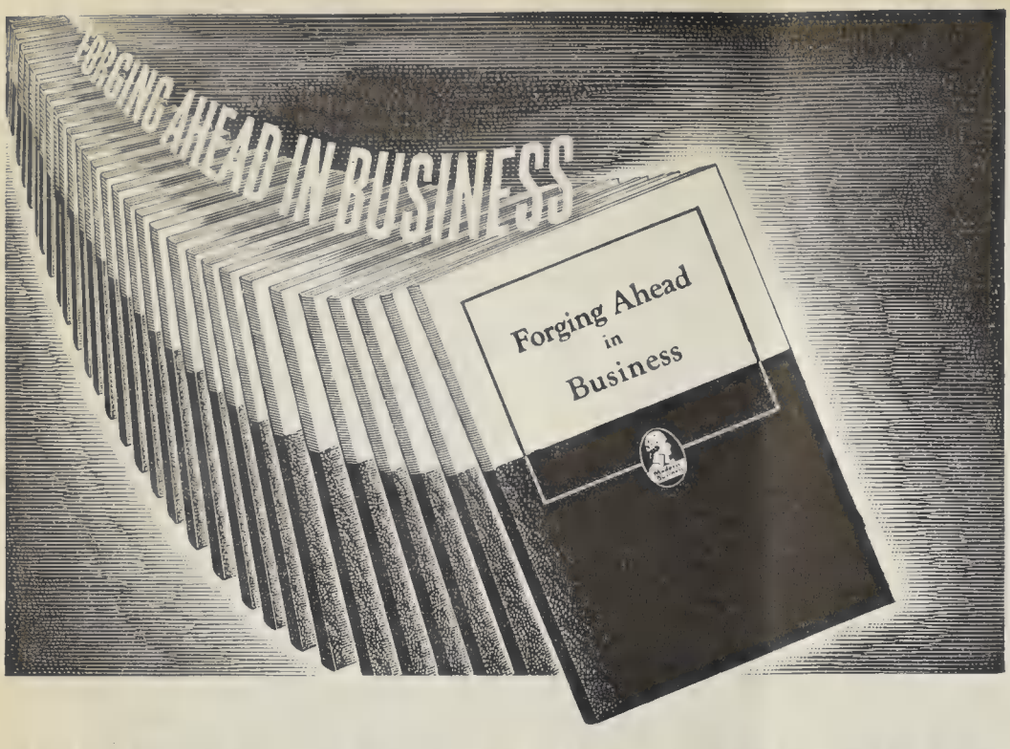
This unique installation is just one example of the many ways that South Bend Lathes are used. Where versatility is valuable and precision is vital, South Bend Precision Lathes offer this important combination of qualities. They are extensively used in the research and engineering laboratories of schools, colleges and industrial plants, as well as for production, maintenance, and service work.

There's a South Bend Precision Lathe to meet your requirements, too. Write for Catalog 100-D which shows all South Bend Engine Lathes, Toolroom Lathes and Precision Turret Lathes in full color.

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Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

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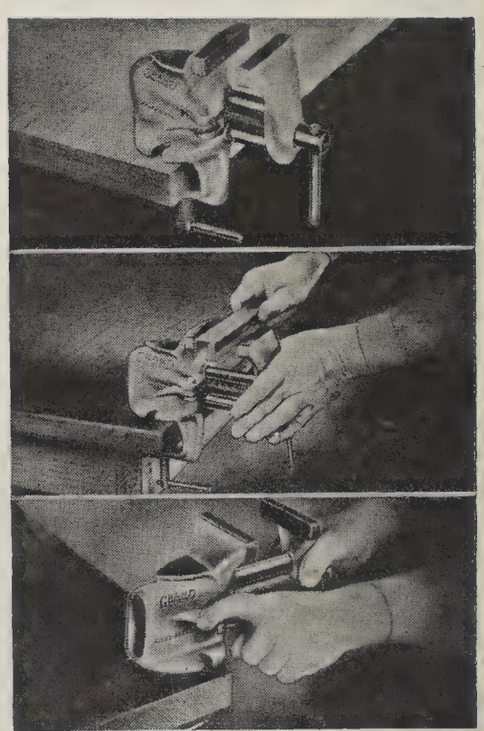
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trode that quarter-inch steel plate 40 to 50 feet below the surface of the ocean, for instance, can be cut at the rate of 62 inches a minute, or considerably faster than ordinary newspaper piled to like thickness can be cut with a pair of scissors in the comfort of your living room.

SPEED VISE

Opens or Closes Without Turning Screw

MANUALLY operated, a new "Quikcet" vise, manufactured by Grand Specialties Company, eliminates running in or out the screw to close or open the vise. It is claimed that this new speed vise can be set and closed in a jiffy by simply pushing on the body of the free jaw, which slides in swiftly on ratchet screw and two precision guide rods and tightens with a turn of the handle. The vise is equipped with a trigger-release pawl with ¾ inch of thread



Trigger releases vise screw

which holds the hardened screw under spring tension. The vise is said to open instantly to full 3 inches by pressure of thumb or finger on trigger release after tension has been eased by a single turn of the loose-proof handle. The Quikcet vise is then ready, without further adjustment, for instant closing on any other work.

ELECTRIC MARKER

Makes 7200 Cutting Strokes per Minute

ANYTHING and everything can be marked with an electric marker just announced by the Ideal Commutator Dresser Company. Although small in size, only six inches long and ten ounces in weight, life tests prove that this new marker can be used continuously on the toughest of marking jobs.

The power of the cutting stroke has been increased by 30 percent over previous models, yet an adjusting nut makes it possible to vary the impact



High speed, variable impact marker

so that it can even be used to mark on glass. Shaped to fit the hand, it can be held and used to write almost as easily as a pencil.

The new marker operates from any A.C. electrical outlet. Working like a small electric hammer, it makes 7200 cutting strokes per minute, cutting right into the surface and leaving lines that cannot be wiped away or worn off with ordinary usage. It permanently marks sizes, names, numbers, and other important information on tools, parts, and finished products.

EXTINGUISHER VALVE

Gives One-Hand Operation of Large Portable Units

TRIGGER control, which has been confined to smaller sizes of carbon dioxide fire extinguishers, has now been extended to the larger portable models. Operated entirely with one hand, the new streamlined Kidde model is controlled by an upward pull of the index finger, the largest extinguisher requiring approximately the same trigger force as the smallest. It can be latched open when desired by a slight forward motion, and as easily disengaged to avoid wasting gas.

This new control represents the perfection of a valve which provides an on-and-off control of discharge with a minimum of effort; permits a high rate



Valve speeds extinguisher action



Through full utilization of new wartime advancements in production methods, manufacturing facilities, and engineering techniques, Jefferson Electric is prepared to meet tomorrow's transformer needs with a product capable of maximum application to postwar technical developments.

The superiority of Jefferson Transformers will continue to be based on such vital and fundamental quality characteristics as: improved steel to reduce electrical losses; advanced methods of using carefully selected iron for laminations followed by Jefferson's own process of annealing; improved compounds, materials and impregnation methods to provide greater resistance to moisture, extreme heat and cold.

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Typical Jefferson Electric Transformers include those for use with radio, radar, television and electronic applications; transformers for control and relays,—for luminous tube and fluorescent lighting,—for mercury lamps, street lamps, X-Ray lamps;—dry type transformers for power circuit stepdown purposes.

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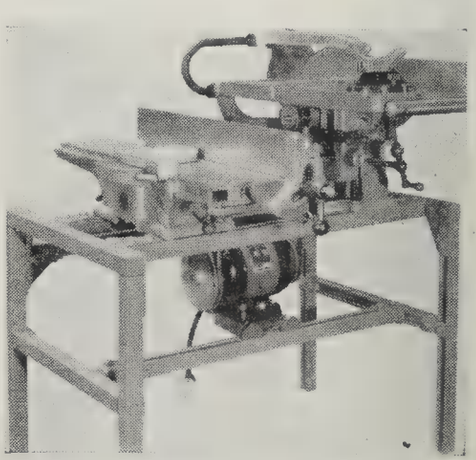
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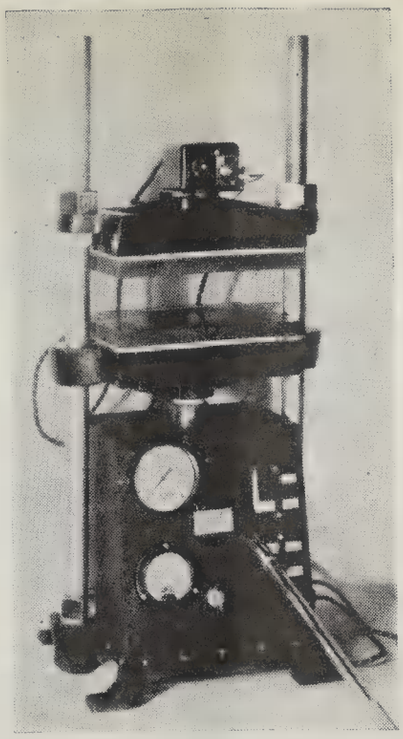
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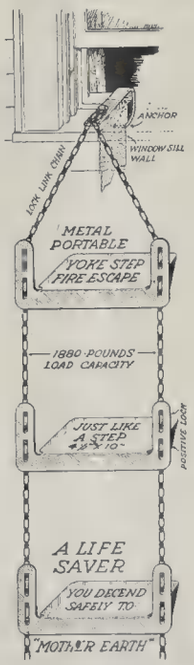
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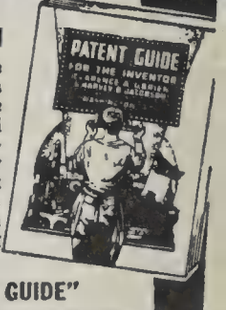
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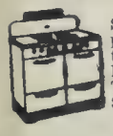
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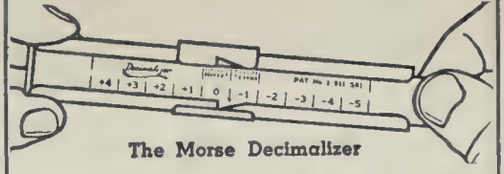
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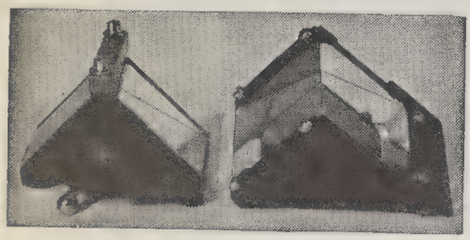
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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

REPRODUCED on this page at 7/16 original size are several pages from Sir Isaac Newton's classic "Opticks" (1704). The selection begins at the fateful point where Sir Isaac made the famous mistake that led him just to miss discovering the achromatic lens principle —but also to invent and make the first Newtonian telescope. In it, the amateur telescope maker of today may see Newton, himself essentially an amateur, at work on the first telescope mirror of record.

First-edition copies of Newton's "Opticks" are sold by rare book dealers at prices current from about $30 to $70. Let not the old-ftyle s of Newton's time difmay you, fince after remarkably little reading it no longer tripf you up.

The first complete sentence on Newton's 75th page begins on line 2 with the word "But," and contains the statement which delayed discovery of the achromatic lens almost a century. After a sketchy experiment Newton had jumped to the conclusion that refractive index and dispersion were proportional, so that by no two-component objective lens dodge could lenses be freed from chromatic aberration. The pundits long blindly accepted Newton's dictum.

Plaintively, Newton next states that, so far as the reflector is concerned, he supposes people would simply have to go on using the same old principle, the one-lens objective of Kepler which had immense focal length to minimize aberrations, and obtain any improvements by still further increasing these focal lengths. But Newton goes on to say that users could at least avoid the long, slender, and cumbersome tubes which this had made necessary by using Huygens' new and really manageable mounting. After finishing with Newton we shall return, in this antiquarian optical amble, to this new Huygens aerial mounting for which Newton puts in so strong a plug.

"I contrived a perspective," Newton writes on the same page. Old term for telescope.

The fraction on the same page, in tiny type even on the original, is 1/5.

While, as Newton states, he stopped his aperture to 1 1/3", this was not the full diameter of his bell-metal speculum, which was 2 1/16". Even then his focal ratio became *f*/4.7, and it is remarkable that this gave performance, especially on a sphere—if it really was a sphere in the lack of a test. But any amateur knows the tendency with a soft lap to work toward the hyperboloid, and maybe Newton luckily landed squarely on the paraboloid without knowing it. He did know a paraboloid was needed, but neither he nor anyone else knew how to figure one.

The bottom line on page 75 refers to a refractor, obviously a Galilean type.

Page 76, line 6, mentions "overcharged." Empty magnification. Beginners still cry for it.

Line 8, "two of these." Of the two telescopes only the second, too often mislabeled the "first," survives. It is at the headquarters of the Royal Society of London, where your scribe once was permitted to examine it. The treasure was perched atop a cabinet at eye level, entirely in the open but in private office quarters. The accompanying photograph was obtained at that time.

The competent workmanship clearly proves that Newton was himself a good amateur telescope maker and mechanic, and there is record that he bought a lathe while at Cambridge University. On that lathe and with his own hands he must have turned up the wooden base, the cup and ball mounting so simple and ingenious, and the eyepiece shell.

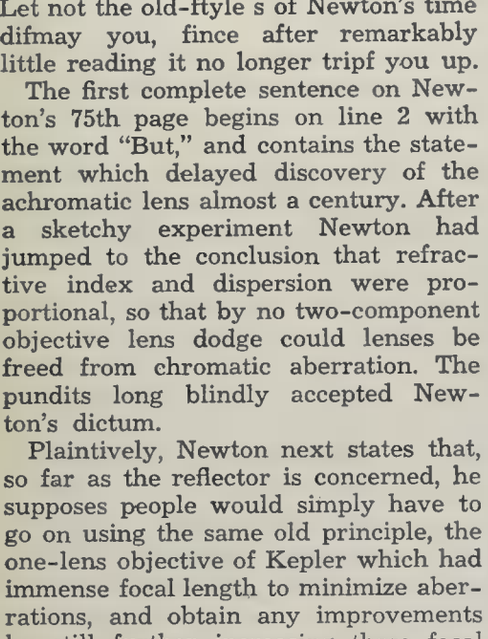
Newton made these two reflectors respectively in 1668 and 1671 and, since they were approximately alike, the question whether the one that survives is the first or the second is, after all, of lesser moment. He and others in 1674 communicated several items concerning them to the Royal Society through its periodical (still being published) the *Philosophical Transactions*. He did not write his book, "Opticks," until about 1687 and then delayed its publication until 1704.

There are replicas of Newton's telescope in the planetariums in Philadelphia and Chicago and in the Buffalo Museum of Science. As a pure sporting proposition, any modern amateur who makes a copy of Newton's telescope might at least consider the whim of foregoing those advantages which Newton could not enjoy, which would prove to be more than at first appears, and afterward ascertaining whether his work would pass the test to which Newton put his telescope. "I found," he writes, "that I could read in the *Philosophical Transactions*, placed in the Sun's light, at an hundred foot distance, and that at one hundred and twenty foot distance I could discern some of the words.

Page 76, "as thin as a groat." Your scribe caught up with a Henry VIII groat at the Scott Stamp and Coin Co. and, though not much worn, it was very much thinner than a badly worn dime.

"Putty" is tin oxide.

RETURNING now to the old long-focus, one-lens Kepler refractors, typical examples of its kind are: 3" lens, 30'

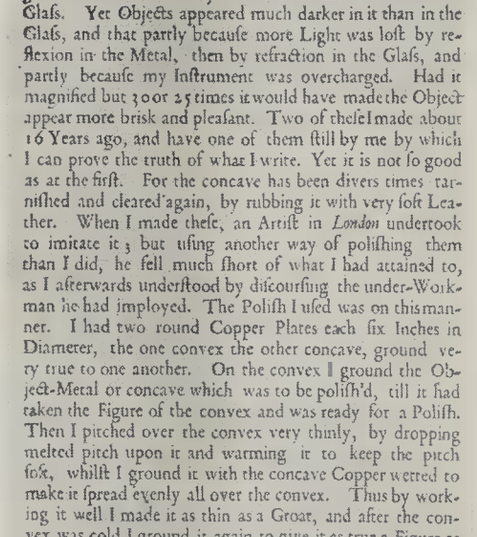


[75]

might Telefcopes be brought to fufficient perfection, were it not for the different refrangibility of feveral ſors of Rays. But by reaſon of this different refrangibility, I do not yet ſee any other means of improving Telefcopes by Refractions alone than that of increaſing their lengths, for which end the late contrivance of *Hugenius* ſeems well accommodated. For very long Tubes are cumberſome, and ſcarce to be readily managed, and by reaſon of their length are very apt to bend, and ſhake by bending ſo as to cauſe a continual trembling in the Objects, whereby it becomes difficult to ſee them diſtinctly: whereas by his contrivance the Glaſſes are readily manageable, and the Object-Glaſs being fixt upon a ſtrong upright Pole becomes more ſteddy.

Seeing therefore the improvement of Telefcopes of given lengths by Refractions is deſperate; I contrived heretofore a Perſpective by reflexion, uſing inſtead of an Object Glaſs a concave Metal. The diameter of the Sphere to which the Metal was ground concave was about 25 Engliſh Inches, and by conſequence the length of the Inſtrument about ſix Inches and a quarter. The Eye-Glaſs was plano-convex, and the Diameter of the Sphere to which the convex ſide was ground was about $\frac{1}{5}$ of an Inch, or a little leſs, and by conſequence it magnified between 30 and 40 times. By another way of meaſuring I found that it magnified about 35 times. The Concave Metal bore an aperture of an Inch and a third part; but the aperture was limited not by an opake Circle, covering the Limb of the Metal round about, but by an opake circle placed between the Eye-Glaſs and the Eye, and perforated in the middle with a little round hole for the Rays to paſs through to the Eye. For this Circle by being placed here, ſtopt much of the erroneous Light, which otherwiſe would have diſturbed the Viſion. By comparing it with a pretty good Perſpective of four Feet in

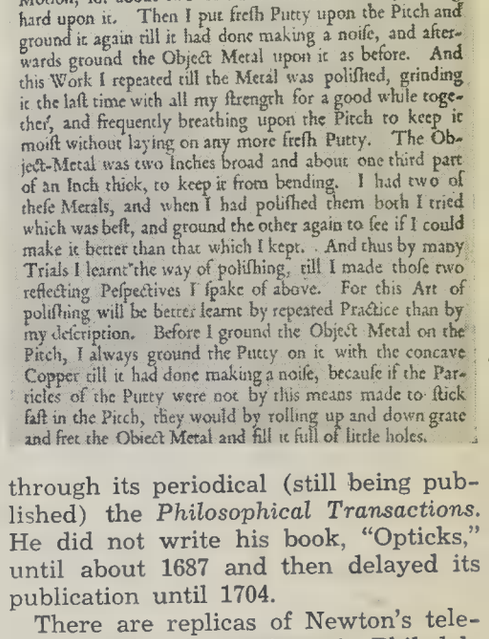
K 2 length,



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length, made with a concave Eye-Glaſs, I could read at a greater diſtance with my own Inſtrument than with the Glaſs. Yet Objects appeared much darker in it than in the Glaſs, and that partly becauſe more Light was loſt by reflexion in the Metal, then by refraction in the Glaſs, and partly becauſe my Inſtrument was overcharged. Had it magnified but 300 or 250 times it would have made the Object appear more brisk and pleaſant. Two of theſe I made about 16 Years ago, and have one of them ſtill by me by which I can prove the truth of what I write. Yet it is not ſo good as at the firſt. For the concave has been divers times tarniſhed and cleared again, by rubbing it with very ſoft Leather. When I made theſe, an Artiſt in *London* undertook to imitate it; but uſing another way of poliſhing them than I did, he fell much ſhort of what I had attained to, as I afterwards underſtood by diſcourſing the under-Workman he had imployed. The Poliſh I uſed was on this manner. I had two round Copper Plates each ſix Inches in Diameter, the one convex the other concave, ground very true to one another. On the convex I ground the Object-Metal or concave which was to be poliſh'd, till it had taken the Figure of the convex and was ready for a Poliſh. Then I pitched over the convex very thinly, by dropping melted pitch upon it and warming it to keep the pitch ſoft, whilſt I ground it with the concave Copper wetted to make it ſpread evenly all over the convex. Thus by working it well I made it as thin as a Groat, and after the convex was cold I ground it again to give it as true a Figure as I could. Then I took Putty which I had made very fine by waſhing it from all its groſſer Particles, and laying a little of this upon the pitch, I ground it upon the Pitch with the concave Copper till it had done making a noiſe; and then upon the Pitch I ground the Object-Metal with a brisk

Motion



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Motion, for about two or three Minutes of time, leaning hard upon it. Then I put freſh Putty upon the Pitch and ground it again till it had done making a noiſe, and afterwards ground the Object Metal upon it as before. And this Work I repeated till the Metal was poliſhed, grinding it the laſt time with all my ſtrength for a good while together, and frequently breathing upon the Pitch to keep it moiſt without laying on any more freſh Putty. The Object-Metal was two Inches broad and about one third part of an Inch thick, to keep it from bending. I had two of theſe Metals, and when I had poliſhed them both I tried which was beſt, and ground the other again to ſee if I could make it better than that which I kept. And thus by many Trials I learnt the way of poliſhing, till I made thoſe two reflecting Perſpectives I ſpake of above. For this Art of poliſhing will be better learnt by repeated Practice than by my deſcription. Before I ground the Object Metal on the Pitch, I always ground the Putty on it with the concave Copper till it had done making a noiſe, becauſe if the Particles of the Putty were not by this means made to ſtick faſt in the Pitch, they would by rolling up and down grate and fret the Object Metal and fill it full of little holes.

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f.l. (*f*/120); 5½" lens, 100′ f.l. (*f*/219); 7¾" lens, 200′ f.l. (*f*/258). The long, slender, floppy, shimmying tubes were skeletonized and braced laterally by spreaders and hung on multiple bridles from tall poles, but in his new aerial mounting Huygens substituted for all this cumbersome gear one single simple silken cord of seven-pound strength (finest modern bait casting line nine pounds test—Abercrombie and Fitch). This line alone linked together and controlled the objective in a delicately counterpoised cell on a ball-and-socket pivot, and the eyepiece.

Details show in the accompanying illustration from Smith's "Compleat System of Opticks" (1738). A little crook in the tail of the cell stick offsets the angle of sag (sketch 614) of the line. Sketch 615 shows the large eyepiece on a stick, the line and its guide, also the violin peg adjustment for f.l. (The scissors-like part is a variable rhombus attachment on a rest, by which a star, once found, could be held long enough to enable an inexperienced observer to get to the eyepiece.) Sketch 616 is a Mr. de la Hire's lens cell control.

The whole, after study, ceases to seem ludicrous.

SOME years ago, in the *Proceedings of the Royal Society of Edinburgh*, the astronomer Sampson and the famous professor of optical design Conrady, with R. Westlake, today professor at the University of Rochester and lens designer for Eastman Kodak, examined, tested, and described three of these old one-lens, long-focus objectives preserved at the Royal Society of London. One was a 7⅞" of 122′ f.l., diamond-signed by Huygens in 1686, together with the original apparatus for adjustment of his aerial telescopes,



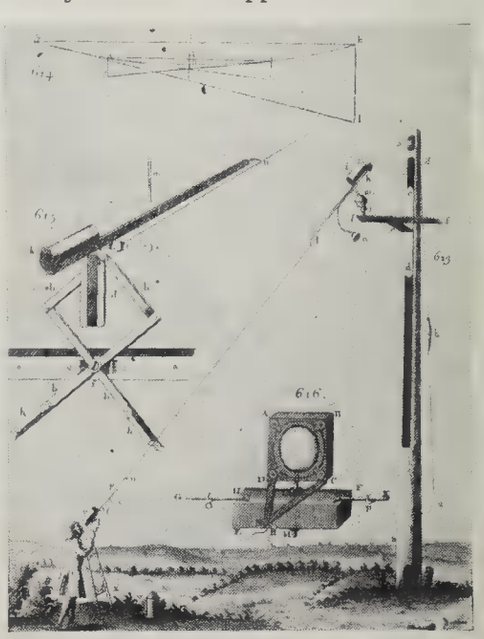
Made by I. Newton, amateur

including eyepiece of 2¼" aperture and 6" f.l. The second was an 8⅜" of 170′ f.l., signed by Huygens 26 June 1686 and later owned by Newton. The third was a 9⅛" of 210′ f.l.

These examiners reported: "In comparison with even the cheapest of modern window or bottle glass, that in Huygens' lenses is extremely bad. Besides numerous bubbles and small stones and frequent black particles of considerable size . . . the entire disks are simply one tangle of innumerable mostly fine veins which would render really regular refractive effects quite impossible." The refractive index for the 170′ was 1.53, for the 210′, 1.58, corresponding to modern plate.

The plano side of the 210′ was found to be "amazingly close to flat." Centering was precise within 0.0016" and 0.0056", yet Huygens centered by miking lens edges with a hand vise.

The two authors add: "There is a widely current misapprehension in the



From Smith, "Compleat System of Opticks" 1738
Huygens' aerial telescope

matter of achromation in relation to these early systems. If the ocular is also a single lens and made of glass of the same dispersion, then for the combination, focused to infinity, the angular magnification is measured by the ratio of the focal lengths, and from this ratio the refractive index of the glass eliminates itself and leaves n function of the curves alone. Hence the image would be achromatic. The case is not so simple as this because the combination cannot be focused to infinity simultaneously for different colors, but a good approximation to it may be reached by focusing in the orange-yellow. We conclude," say Sampson and Conrady, "that the chromatic faults of these combinations were less noxious than is generally believed."

Suppose a Kepler-Huygens aerial telescope were today or post-war made and set up beside a Newtonian of comparable aperture as a demonstration, what widespread attention it would attract! Utility, low. Scientific demonstration value, interesting, somewhat instructive. Such stunts should, however, be done for the fun of it—justification enough.

A few possibilities, from a table of Huygens' standards, are: a 5.48" of 100′ f.l., hoisted up and down on a 75′ pole, eyepiece 6.03" f.l. Or a 3.87" of 50′ f.l., with 4.26" eyepiece and a 40′ pole.

Specific directions for ordering from large libraries photostats of the Newton, Smith, and Sampson-Conrady writings, giving working data, are available from this department.

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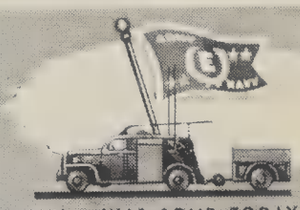
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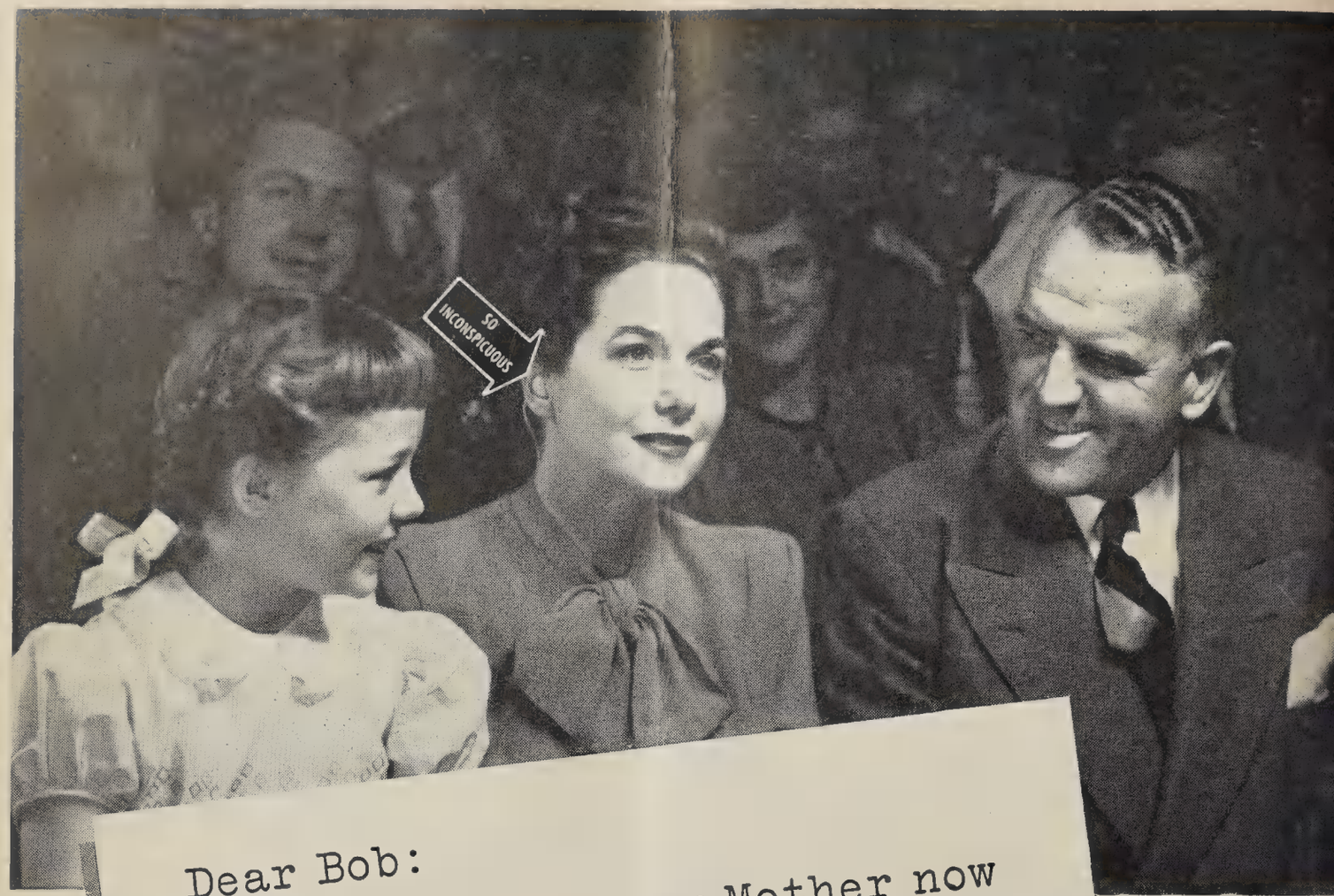


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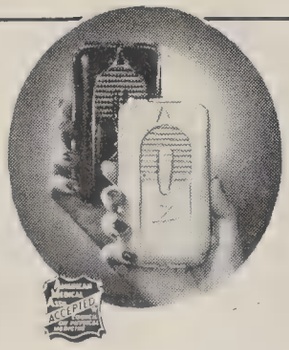
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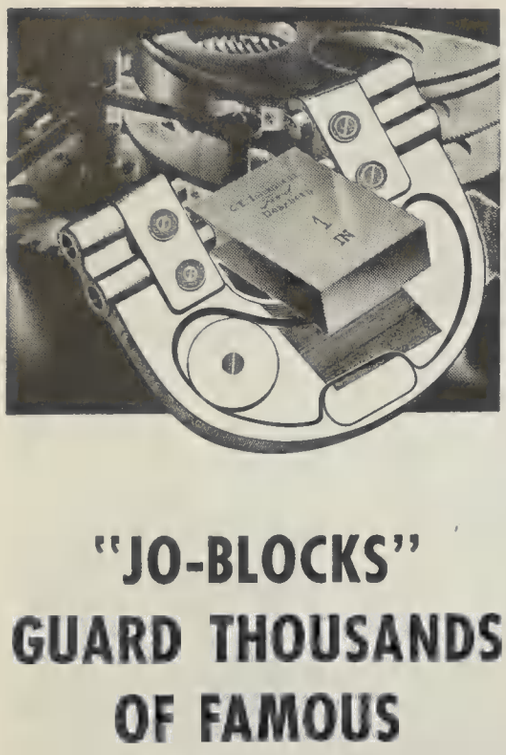
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Our Cover: Welding as a major tool of the ship builder has been amply proved during World War II. How early troubles in the process have been overcome is told in the article on page 218.

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and

here's a kiss for being *you*—a woman with brains enough in your pretty head to make sure we don't buy a single thing we *don't* need in times like these—because you know a crazy wave of spending in wartime would march America straight into inflation. Baby, I sure knew how to pick 'em the day I married you!

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Previews of the Industrial Horizon

By A. P. Peck

TRANSOCEANIC

More than one shipping man believes, and with excellent justification, that the days of huge, fast, transatlantic liners are past. These luxury ships, never wise investments from a financial standpoint, served their greatest purpose in building up the national prestige of the country of origin and in inflating the ego of some of the passengers. To a certain extent they were valuable means of transportation for a few to whom time really meant money, but for those few the airplane now offers even greater time savings and with a high factor of safety.

This is not to say that the airplane is going to supersede the steamer for transocean travel. As Dr. Klemin points out in the article starting on page 228, airlines offer many desirable features but there will be vast numbers of travelers who will prefer the slower, more leisurely pace of the surface ship whether pleasure or business bound. And those ship operators who provide average-size vessels, of moderate speed and with comfortable accommodations, are going to carry the great bulk of transocean traffic for a long time to come.

SKY-HOOK TELEVISION

What seems, at first glance, to be a brain-child of a wild-eyed dreamer is the recent proposal to put television transmitting equipment in airplanes, send the planes to an altitude of six miles, and broadcast television programs from that vantage point where the electrical limitations of ultra short-wave transmission almost vanish. But the proposal has the backing of Westinghouse and The Glenn L. Martin Company and therefore merits more than passing attention.

Aircraft reliability has been proved. To keep a fleet of planes in the air 24 hours a day, day in and day out, can easily be done by providing "spares" and operating the ships on an eight-hour schedule with one broadcasting and one stand-by plane in the air at each station at all times.

Not only would the six-mile altitude of the transmitters extend the line-of-sight range of ultra short waves to over 400 miles, but the power required to cover that range would be relatively small. Thus, with only eight "Stratovision" stations in operation, a coast-to-coast network could be established that would require about 100 ground relay stations to provide comparable service. The television programs would be beamed to the planes from low-power ground stations.

Airplanes are expensive to build and maintain; so are short-wave radio relay stations or co-axial cable systems. In Stratovision a number of television and FM programs would be broadcast simultaneously from each airplane. When the technical possibilities of airplane versus ground television networks are considered and the comparative costs are carefully balanced, it appears that the "brain-child of a wild-eyed dreamer" is actually a view of the not far distant future as seen by a group of realistic engineers.

PACKAGED POWER PLANTS

Complete steam plants, assembled at the factory, tested, and shipped ready for operation as soon as fuel, electric, and water connections are made, promise to furnish competition to Diesel and gas turbine plants in the future. These steam plants, far more compact than conventional units of the same capacity, depend for their efficiency on a baby boiler of the flash type employing forced circulation of feed water. By coiling the boiler tubing into a compact pancake shape, the hot gases from the fuel reach all parts of the tubing simultaneously; the result is rapid steam production at high pressures and at high efficiencies. The tubes used are relatively small in size but the reduction in water capacity is made up for by the use of circulating pumps. The steam goes directly from the boiler to the turbine, so that no steam storage is necessary.

Such small steam generating plants have wide possible applications. Because they are made in sections, they can be tailored exactly to fit any need. The sections give the added advantage of rapid repair in case of failure; the damaged section is merely cut off and fixed while the remainder of the plant remains in operation. Chemical plants, laundries, food processing plants, yachts, and so on, will be potential markets for these plants.

ELECTRICITY ON THE FARM

Electrification of America's farms interests many people. The farmers themselves, the manufacturers of farm equipment, electrical power companies, and a number of allied industries all have a stake in it. Simply stated, more power on the farm means more efficient production of farm commodities and hence more farm income. And when the farmer prospers, so prospers the nation.

From published reports it appears that farms in California will be practically 100 percent electrified within the next three years; New Jersey and Rhode Island will run almost neck and neck, but many other states will still be far behind. Texas, as of now, has less than one third of its farms electrified, as do also several of the mid-western states. From this it can be seen that there is a wide-open rural market for power and power-using equipment.

Diesels are going to make a strong bid for much of this market, and it is still a question as to whether these prime movers or the power companies will get there first. One available set of figures runs like this: During 1944 the production of Diesel power for the American merchant marine alone totalled 136,850 brake horsepower. Just this one phase of the Diesel engine industry thus produced facilities sufficient to furnish electric power to more than 3 percent of the total number of American farms now lacking that power.

FOR FUTURE REFERENCE

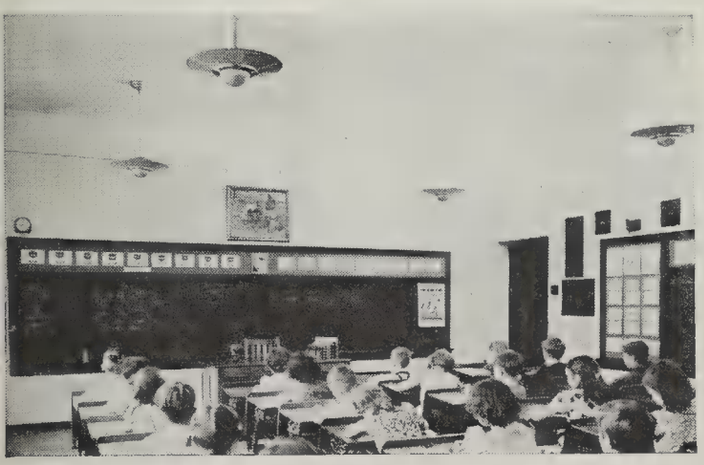
Concrete to which has been added a lignin product made from paper-mill waste is reported to be stronger, less porous, and to last longer than when made from conventional ingredients. . . Watch for a tremendous increase in the number and variety of coin-in-the-slot machines vending everything from bread, stockings, and fresh orange juice to sizzling "hot dogs"; watch out also for rackets connected with these machines. . . Containing no petroleum, a new synthetic lubricant is reported to have unusual stability at high and low temperatures; it will be high in cost but for many uses will have overbalancing advantages. . . "Protective coatings," all-inclusive name for paints, varnishes, and lacquers, are taking into the fold many of the newer resins and will soon offer outstanding protection under most adverse conditions of exposure. . . Styrene, wonder-child of chemical industry and ingredient of synthetic rubbers for many uses, can be the base of foamed insulating material, high-quality varnishes, plastics of various types, water-emulsion paints, water-proofing compounds, and many other industrially important substances. . . Midget tractors, from 10 horsepower up, selling for around $500, will shortly appear literally in droves from a number of manufacturers, offering the farmer versatile equipment for lightening his labors. . . No atomic bomb or power story on this page; it's on page 238.

Outwitting the weather

How science copes with Old Man Weather is illustrated by these ideas and devices from General Electric laboratories.

How high are the clouds? A ceilometer measures this for airmen. How wet is the weather? Hay can now be stored in barns before it is dry, with a new hay-drying system with G-E control. And one G-E laboratory makes weather—with or without rain, wind, sleet, snow—to test G-E turbo-superchargers.

On this page are a few more examples of the way General Electric research and engineering are being devoted to this phase of human comfort and health.
General Electric Company, Schenectady, N. Y.



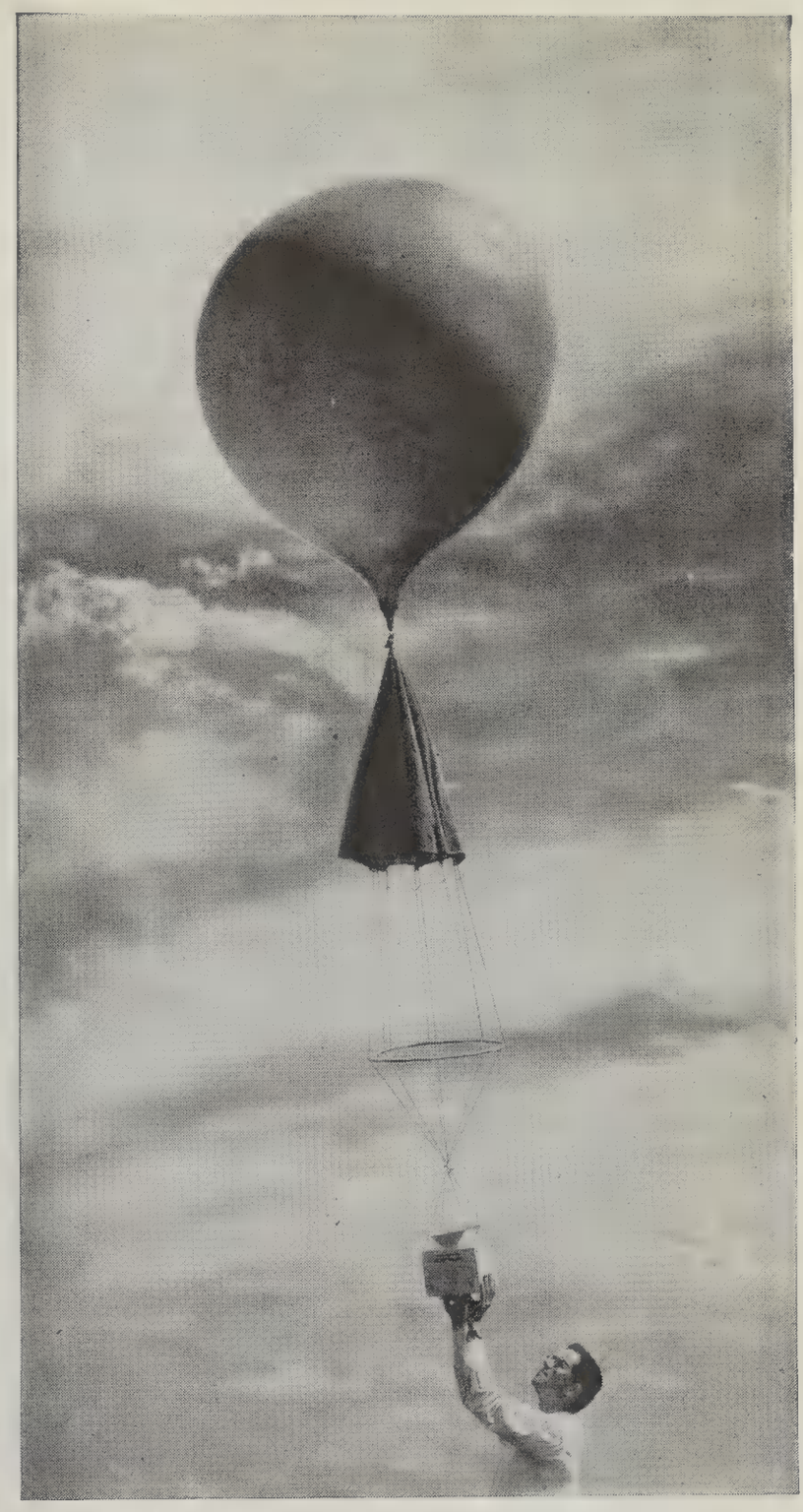
Cloudy but bright. When clouds darken the sky, lights come on in this schoolroom. No one has to remember; a General Electric automatic light control with an "electric eye" keeps constant watch, safeguards young eyes by turning on the lights whenever needed.



Cucumber magic. Vines in electrically heated soil (right) grew twice as tall, and bore one month earlier. A heating cable, developed by G-E engineers, is buried in the soil and thermostatically controlled. More than 15,000 commercial growers use G-E soil-heating cable.



Spring weather. Cool, mountain-top comfort in your bedroom, or anywhere else in your house, will be provided by G-E air conditioning units. Nor have G-E engineers forgotten winter problems; they have applied G-E research and engineering to home heating systems, too.



Weather detective goes aloft in the small box suspended from the balloon. Some 12 miles up the balloon bursts, and the box is parachuted back to earth. On the way up, this electronic device, called the G-E Stratometer, gives a running commentary on the weather—temperature, humidity, air pressure—and sends this information back to earth by radio signals. The information gathered by the G-E Stratometer can be used to help predict weather.

★ ★ ★

Hear the G-E radio programs: The G-E All-girl Orchestra, Sunday 10 p.m. EWT, NBC—The World Today news, *Monday through Friday 6:45 p.m. EWT, CBS—The G-E House Party, Monday through Friday 4:00 p.m. EWT, CBS.*

FOR VICTORY—BUY AND HOLD WAR BONDS

GENERAL ELECTRIC

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of October, 1895)

"BROOKLYN" — "In the building up of our new navy, the United States government have reaped much benefit from the fact that they were a little late in starting. While other nations have expended large appropriations on ships that were largely in the nature of experiments, we have been in the position of the critical onlooker; and the costly fail-



ures of other naval boards have been valuable object lessons to our own as to what to avoid. The outcome of this observation is seen in a class of ships which, while they embody the best features of European practice, are yet marked by the strong originality which ever characterizes American design. The *Brooklyn* is spoken of as a sister ship to the *New York*. . . She should be more properly called an enlarged and improved *New York*, being 14 feet longer and of 1,000 tons more displacement."

LOCOMOTIVES — "Is the electric locomotive to supersede the steam locomotive as the future tractive power on our railroads? . . . Unless a system of stationary boilers and engines can be produced that will furnish the electric locomotive with its power for one-half the coal consumption that is necessary for the generation of the same power in the steam locomotive, we may rest assured that George Stephenson's invention will remain among us for years to come as the greatest triumph of the modern mechanical world."

OPTICAL WORKS — "Some idea of the magnitude of the Carl Zeiss Works may be gathered from the fact that it requires three hours to pass through the various wings and departments, without leaving much leisure for inspection of details. Upward of 500 workpeople are employed, a curious feature being that there is no difficulty in obtaining skilled workers in metals, but the optical hands have to be trained within the works from boyhood."

INVENTION — "Young men of an inventive turn of mind should be constantly on the alert, observant in everything. Note where a saving of time or material can be effected by improved methods. If you cannot make two blades of grass grow in the place of one, invent some method to do certain things quicker and better than by present methods. Time is money, and any method by which time is saved has a commercial value. If the operation is performed better and quicker, the commercial value of the method or means enhances accordingly. The simplest inventions are of the most value, comparatively. A recent report from the Patent Office states that the majority of successful patents were for articles that retailed for one dollar or less."

VENTILATION — "Although the summer of 1895 has now departed, the ever-present and perplexing question of the ventilation of passenger cars is still here. It is true that the question of ventilation will soon assume a different phase; will become a question of how to get warmth into a car instead of how to get it out; but the troubles of the day car passenger in summer are very real, and will recur again next summer as surely as the world rolls round."

PASTEUR — "If the measure of human greatness is to be found in the amount of blessedness that a man's life and work bring to his fellowmen, there has lately passed from our midst one of the greatest of all great men. The moral philosophers tell us that the pursuit of pleasure and the avoidance of pain are chief among the natural instincts of man. If this be so, Pasteur has done more to ameliorate the condition of the race than any one man, living or dead."

HYDRAULIC POWER — "In the course of a paper read at the recent summer meeting of the Institution of Mechanical Engineers, at Glasgow, the author, Mr. E. B. Ellington, gave some very significant figures regarding the cost of running the London Hydraulic Power Supply. This is by far the largest municipal supply in the country. It includes 75 miles of mains, carrying a pressure of 750 pounds to the square inch, which deliver 9,500,000 gallons of water at this pressure per week. This serves to operate 2,300 machines. This plant has now been in operation for twelve years, and it yields an annual revenue of $250,000."

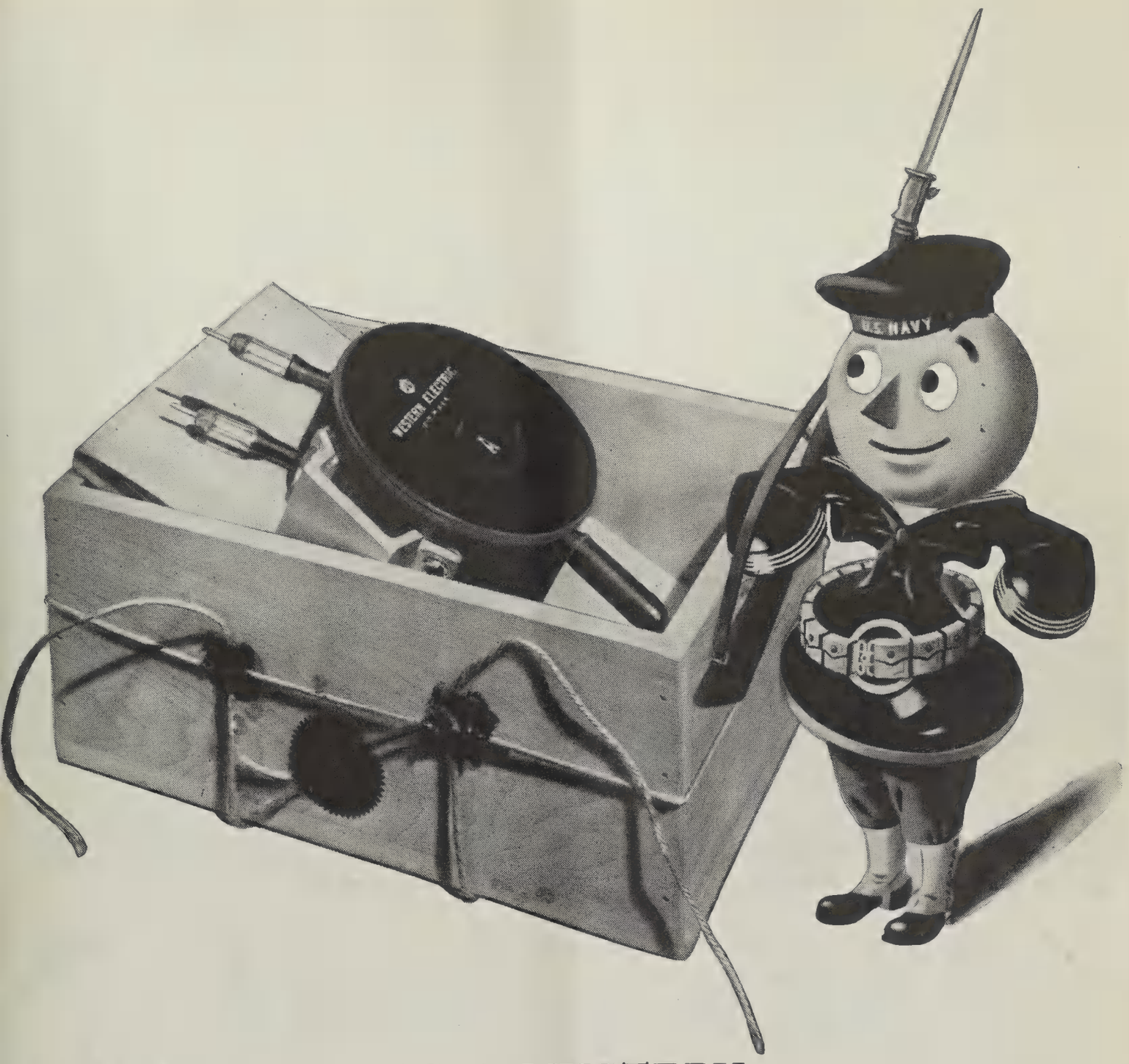
NEWS BY TELEPHONE — "The telephone newspaper organized at Pesth, Hungary, has now been working successfully for two years. . . It has 6,000 subscribers, who receive the news as they would ordinary telephone messages. A special wire 168 miles long runs along the windows of the houses of subscribers, which are connected with the main line by separate wires and special apparatus which prevents the blocking of the system by an accident at one of the stations. Within the houses long, flexible wires make it possible to carry the receiver to the bed or any other part of the room. To fill up the time when no news is coming in, the subscribers are entertained with vocal and instrumental concerts."

RECLAIM — "The business of gathering waste rubber is chiefly confined, so far, to cast-off foot-wear. The methods of reclaiming rubber were first applied to scrap of this class, and the organized channels through which 18,000 tons of scrap annually trickle from the hands of country peddlers into larger streams, until the rubber reclaiming factories receive it in carload lots, have all been planned for the collection of old shoes."

NIAGARA — "The Niagara Falls Hydraulic Power and Lifting Company have recently contracted with James Leffel & Company, of Springfield, Ohio, for four of their improved double discharge water wheels, to be of eight thousand horse power capacity, under a maximum head pressure of 218 feet, which is far the highest head under which turbines of large capacity have ever been applied in this country or elsewhere. These wheels will drive eight electrical generators, which will be connected direct to the turbine shafts, without gears or belting."

DUST EXPLOSIONS — "Flour, coal dust, and other fine organic dust, explode when certain outside causes are present. Professor Tobin demonstrated before the Kentucky Millers' Association this fact, and further showed that dampness destroyed the explosive tendency. Live steam was recommended as a preventive, by damping the air of the mill. The same would apply to the air in a woodworking factory, where it is full of dry dust."

PARIS GREEN — "It is estimated that more than two thousand tons of Paris green are annually used as an insecticide in the United States, since it is the most rapid and effective of the arsenical preparations used for this purpose."



VICTORY REVEALS A MYSTERY

More than two years ago, an engineer of the Laboratories visited *U.S.S. Boise*, returned with a mysterious box which went into the Laboratories' vault. Now, victory opens the box and discloses a special kind of electron tube called a magnetron. It was part of a Radar which furnished data to aim *U.S.S. Boise's* guns during the night action off Savo Island on October 11-12, 1942. Because of the high frequency generated by this magnetron, the Radar was not detected by the enemy and the action was a complete surprise. Six Japanese warships were sent to the bottom of the sea.

This magnetron is a symbol of the Laboratories' enormous war program. Half of it was devoted to Radar, the other half gave birth to radio transmitters and receivers, sonar apparatus for the Navy, loudspeaker systems for ships and beach-heads, fire-control apparatus for anti-aircraft artillery. Coming months will unfold the story of these and many other contributions of the Laboratories to the victory of our arms.

Bell Telephone Laboratories' war work began before the war; until now, it claimed practically all our attention. With victory, we will go back to our regular job—helping to bring you the world's finest telephone service.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting, for continued improvements and economies in telephone service.



Pride of the Navy in 1855

• The U. S. Frigate, *Wabash,* launched in 1855 marked a revolution in naval development. For the first time, steam was coupled with a screw propeller.

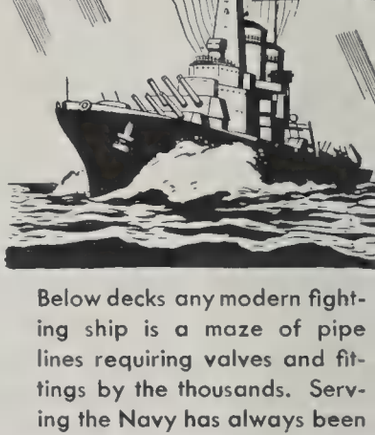
It is significant that the very year that saw the launching of the *Wabash*, also saw the founding of Crane Co. For in 1855, R. T. Crane opened his little foundry— forerunner of the plant that was later to provide so much of the essential piping that made the utilization of the new force of steam power possible.

It is a far cry from the early full-rigged frigates to our present mighty Navy that has hurled an enemy back across thousands of miles of hostile waters and planted the Stars and Stripes on that enemy's shores.

We take pride in the part Crane valves and fittings have played in aiding our Navy to build faster ships, more powerful ships, to defend our country against aggression.

We take pride, too, in the service Crane equipment has rendered industry during the past 90 years in meeting insistent demands for piping to stand ever increasing pressures and temperatures — to withstand the destructive forces of corrosion.

The Crane line includes everything for every piping system. Crane Branches and Wholesalers are within reach of every industrial plant in the country. CRANE CO., General Offices: 836 S. Michigan Avenue, Chicago 5, Illinois.



Below decks any modern fighting ship is a maze of pipe lines requiring valves and fittings by the thousands. Serving the Navy has always been considered a privilege by Crane Co., for the Navy's exacting demands are a tribute to Crane quality.

CRANE

90 YEARS OF 1855 1945

VALVES • FITTINGS • PIPE

PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS

Scientific American

OCTOBER · 1945

* 100th Anniversary Year *



From a Courier and Ives print

The Clipper Ship *Dreadnought*, of 1854

America on the Sea

After Finding that Wooden Ships and Sail Could Not Compete with Iron Ships and Steam, American Shipbuilding Progressed Slowly Until the Turn of the Century Brought in the Practical Use of Fuel Oil and the Development of Better Engines. America's Background of Technical Knowlege has Made it the Greatest Marine Power in the World, but What Will be Done, Post-War, With the Ships now in Being or Being Built?

By **HARRY BOTSFORD**

Editor of "Ships"

FROM earliest Colonial days to the present, American shipbuilders have been pioneers, rather than being content to follow traditional practices. As early as 1527, shipwrecked explorers, led by Luis Vasquez D'Allyon, built a vessel on the banks of the Cape Fear River, not far from the site of one of the busiest present-day shipyards. This was probably the first ship constructed on what is now American soil. Eighty years later settlers of the ill-famed Popham Colony of Maine built *The Virginia,* a ship of 30 tons burden, which made at least one recorded voyage across the Atlantic.

Americans became a nation of shipbuilders because ships were the major form of transportation in an era when few roads or trails existed. Colonial expansion followed a very definite and explicit pattern because the growth of the colonies was at first confined exclusively to coastal areas. From the coast, the migration was inland, up the great rivers. Trading and communication between various points was made possible by a large variety of specialized local craft, built to fill special and urgent needs as to size, draft, and type of service in which the ship was to be used. This naturally

was responsible for a large number of small but busy coastal shipyards, manned by men who were real craftsmen, highly skilled in the use of shipbuilding tools.

Out of these yards came vessels that gave this nation maritime prestige and stature in a world that was a trifle skeptical as to whether the New World was important.

From Colonial days until 1845, our ships played an important part in the economic growth of the nation and in its defense when forced to fight two major wars with a great and aggressive enemy to establish the right of all peace-loving nations to share the sea commerce of the world.

In the interim, so many wooden ships were built in the United States that fine forests were partially denuded in the coastal areas. However, American ships of sail were known and respected throughout the world. They were fast, able to weather storms, to carry what is today known as a "pay load." They were manned by men to whom the sea was an honorable career and a profitable one.

American whalers were specialized ships, the best of their kind. There were hundreds of them. They were to prosper until 1859, when the world's first artesian oil well was drilled in Pennsylvania, giving the world a cheap lubricant and illuminant. The decline of the whaling industry was rapid from this time on.

Packet lines to Europe excited the admiration and envy of other nations; American mariners were venturesome, courageous, and intelligent.

The clipper type ship was born of necessity. By 1848, the demand for such fast sailing ships had reached a new peak. The discovery of gold in California created an active and urgent demand for fast passenger and cargo ships to ply between the East and West coasts. Rates were high and ship owners prospered.

Before this time, however, a curious and expensive error had been made. The rest of the maritime nations, including England, were starting to build iron ships, powered with steam. True, America had built a few such ships, but they were largely looked upon as mechanical innovations, ingenious toys that were interesting, but probably not profitable nor practicable to operate. The vast but shrinking timber resources of the United States were weighed, together with the thousands of men trained in the art and science of building superlative wooden ships of sail—and the canny New England ship operators viewed the cost of boiler fuel as against



From Scientific American, 1862

The iron-plated rebel steamer *Merrimac*



From Scientific American, 1862

The *Monitor*. When in action, the turret awning was removed, together with smokestacks and air pipes



From Scientific American, 1867

The steam ram and battery *Dunderberg*, built in America for the French government

free wind. The result was a solid front against doing anything toward the adoption of steam and iron ships.

Americans clung stubbornly to sail, pinning their faith on fast clipper ships. It was an unwise decision. Slowly but inexorably, Britain and other steamship-minded nations started to take the maritime business away from the United States. Ship operators discovered, to their horror, that a ton of steam was equal to three tons of sail. American maritime industry could not compete with iron and steam. It was not dissimiliar to trying to use draft horses to compete with a motor truck.

STEAM RECOGNIZED—By 1840, reluctantly and belatedly, the value of iron ship construction and steam propulsion was recognized by some in the United States. Shipyards workers did not relish the change. A man trained in the use of woodcutting tools looked with scorn on iron as a basic ship material. He was forced, however, to lay aside the adz, broadaxe, plane, and other woodworking tools for the sledge, the forge, the wrench. It was not an easy transition, and progress was pitifully slow.

Several shipyards were forced to have parts of small iron ships fabricated in England and brought to this country, where they were joined together. Naturally, this was an expensive process. It was one that was limited and restricted to small craft for coastal purposes.

It was not until 1843-44 that America really became a factor in the construction of iron steamers. Harlan & Hollingsworth, a Wilmington, Delaware, shipbuilding concern, were the pioneers. They constructed the *Bangor,* the first iron sea-going steamer built in this country. The stem and forefoot were of advanced design. The ship was of 231 tons burden, 120 feet between perpendiculars, with decks 131 feet in length.

The power plant consisted of independent engines, one for each of two propellers. The cylinders were 22 inches in diameter with a 24-inch stroke. The propellers were of the Topes type, 8½ feet in diameter. The boilers were in the hold, 20 feet long, of the drop-flue type.

Commissioned in 1844, the trial trip was made from Wilmington to Cape May, to Philadelphia, and return. About 150 passengers were aboard. The ship performed well, but the engines proved to be rather inefficient. However, it was not necessary to resort to sails. The *Bangor* carried three wooden masts, schooner-rigged. Caution dictated their installation, for steam was still something of an experiment, and the owners were taking no chances.

In a measure the trial run was satisfactory. At no time did the boilers carry more than 46 pounds of pressure. The average speed was 10.61 miles per hour. The *Bangor* went immediately into coastal service, but burned and was beached within the year. She was salvaged and reconstructed, and for four years operated profitably on the East coast, between Maine and Texas. After that, there is no record as to what happened to the *Bangor,* the first American iron steamer.

The first dramatic years of the Civil War marked a sharp drop in American merchant tonnage, due to sinkings. It likewise marked the advent of the blockade runners of the South, fast vessels that were competently handled and often managed to elude Federal gunboats and take precious cargoes of cotton to England.

During the war period, however, there was little if any advance in merchant ship construction. On the other hand, American naval design did make one highly important advance, one so radical that two newly designed warships figuratively sank every wooden navy in the world.

The *Monitor,* designed by Captain John Ericsson, was laid down at the Continental Iron Works in New York in October of 1861 and was completed in 100 days. The design incorporated at least 40 patentable features, and the completed ship was a curious appearing craft, the most important advance in naval construction to that time.

The turret of the *Monitor* was a startling innovation. It consisted of a short cylinder nine feet high and twenty feet in diameter resting on the deck. It was covered with a grating of iron rails, equipped with sliding hatches. The turret was constructed of wrought iron plates, eight in number, each one inch thick. The plates were accurately faced and firmly bolted together. A flat, broad ring of bronze was let into the deck, making a water-tight joint for the turret.

Ericsson's own description of the machinery was: "The motive engine, the construction of which is somewhat peculiar, consists of only one steam cylinder with pistons at opposite ends, a steam-tight partition being introduced in the middle. The propeller shaft has only one crank and one crank-pin, the difficulty of 'passing the centers' being overcome by the expedient of placing the connecting rods, actuated by the steam pistons, at



From Scientific American, 1867

The steamer *Dean Richmond* of the People's Line, New York to Albany

right angles to each other. The propeller being of the ordinary four-blade type needs no description . . . ." The diameter of the propeller, according to the records, was nine feet. The height of the smokestacks, under non-combat maneuvering, was six feet, and the blower pipes extended above deck a matter of about two feet. In action, however, stacks and blower pipes were cleared away.

While the *Monitor* was being hastily constructed, the Confederate ship *Virginia,* formerly the U. S. Frigate *Merrimac,* was being converted to an ironclad of a different and radically new design. Before the arrival of the *Monitor,* the completed *Virginia* created havoc by destroying several Federal warships of wooden construction, their cannon fire glancing harmlessly off the *Virginia's* slanting armor. It was the *Virginia,* in reality, that first proved to a startled world that wooden warships were helpless under the attack of an ironclad. The fear aroused by the evident power of the *Virginia* was the main factor that caused day-and-night work on the *Monitor,* which was still far from complete as a tug towed her to Hampton Roads, leaving New York on March 6, 1862.

On March 9th, the two completely new types of warships met, the first historic encounter between ironclads. The resulting engagement proved only that, essentially, one ironclad was a match for another.

The activities, the evident potentialities of the ironclad, however, completely revolutionized naval architecture, spelled the doom of wooden warships, and ushered in a new era of naval warfare.

OIL AS FUEL—Following the end of the Civil War, American maritime progress, in both merchant and naval vessels, was slow and cautious. Yet only a few of the experiments failed. Notable was the Navy's first experiment in 1867 of burning fuel oil. The test proved to be abortive and the adoption of fuel oil was delayed for at least a quarter of a century.

Crude oil as a fuel was first used in a Russian ship in 1861. The atomizing principle, introduced a few years later, had a shipboard trial in 1870. It was used in some American warships as early as 1902, but at least another decade was to pass before it came into general use in boilers on merchant ships of the United States.

At first, because of the high price of fuel oil, cost was prohibitive. However, as refining processes improved and as the production of crude oil increased, fuel oil became a by-product of refining and became available at extremely low prices. Low fuel costs gave American ships a small but important economic advantage over foreign flag ships owned by nations not fortunate enough to have a great and expanding oil industry.

The growing oil industry demanded specialized types of ships for the transportation of their products. From 1870 through to the present day, American tankers have always been the finest ships of their type ever designed or built. A modern tanker may cost as much as $3,000,000 and be able to carry 140,000 barrels of petroleum products thousands of miles. The modern tanker is fast, able to slide alongside a modern warship and refuel while both ships are under way. This practice has given American ships an extreme cruising radius. Time was when a warship could only steam so far from a coaling base and then had to return for refueling. Oil is a cheap, dependable fuel, easy to store, and, above all, relatively easy and fast to handle at all times.

In some respects, advancement in naval architecture stemmed from the United States Navy. In 1850, the Navy first tested out forced ventilation, an innovation that later was generally adopted in all types of mechanically propelled ships and one which gave engine-room crews a comfort they never dreamed was possible.

One of the most forward steps in the maritime field was the passage in 1883 by Congress of a Bill which authorized the construction of the first all-steel warships for the United States. The measure specifically stated that all steel to be used in the construction of the warships *Atlanta, Boston, Chicago,* and *Dolphin,* was to be of domestic manufacture.

The steel industry immediately responded, and the encouragement given it by this measure was to be a major factor in the subsequent growth and skill that today characterizes the American steel industry and which makes it the best and biggest in the world.

Metallurgy played an important part in the develop-

ment of shipbuilding in the era from the Civil War to the turn of the century. Steel-making was rapidly advancing and new techniques of rolling in the mills had a direct influence on the size of the steel plates for the hull. On the famous *Great Eastern,* launched in 1858, these plates could be but 33 inches wide and 10 feet long. Forty-one years later in the second *Oceanic,* the plates were 4½ by 25 feet; 11 years later the plates used in the *Olympic* were 6 by 30 feet. Riveting, later to be largely displaced by welding, became faster. Once it took five men to head one rivet; now it is done by two men, and done faster.

BETTER ENGINES—About 1881, according to historical records, the triple-expansion engine began to replace the compound engine. As a result, the speed of some American warships increased to 19 knots. Later, several naval craft were equipped with vertical triple-expansion engines. On the torpedo boat *Ericsson,* these engines performed magnificently, according to accounts of the day. With a steam pressure of 250 pounds, and at 264 revolutions per minute, the ship was driven at a speed of 21 knots. The boilers were regulated by blower engine throttles in the engine room. In a three-hour test run, the *Ericsson* was driven at 22.5 knots and two pounds of coal were burned per hour per indicated horsepower, a notable record for the period.

The application of the steam turbine engine to our steamships dates back to 1894, but the development was necessarily slow because of certain difficulties encountered. For example, the turbine principle could not be put into practical use until modern alloys and metallurgy permitted the necessary high peripheral speed—this in turn could not be brought about until electronics developed in certain directions.

In 1894, the *Turbinia* was built, fitted with turbines. The ship was not accepted, however, until 1897. The *Turbinia* proved to be a power laboratory which speeded up the development of this type of ship.

The first Diesel engine was used as a power plant on a ship in 1902. The Diesel, using a cheap fuel and with no complicated electrical units, became popular by 1910 when the first ocean-going motorship, the Dutch tanker, *Vulcanus,* a 1200 deadweight ton ship, made a successful crossing of the Atlantic.

The following year nearly 400 Diesel-powered ships were in process of construction by various nations. Probably the most famous Diesel-powered ship known today is the *Gripsholm.*

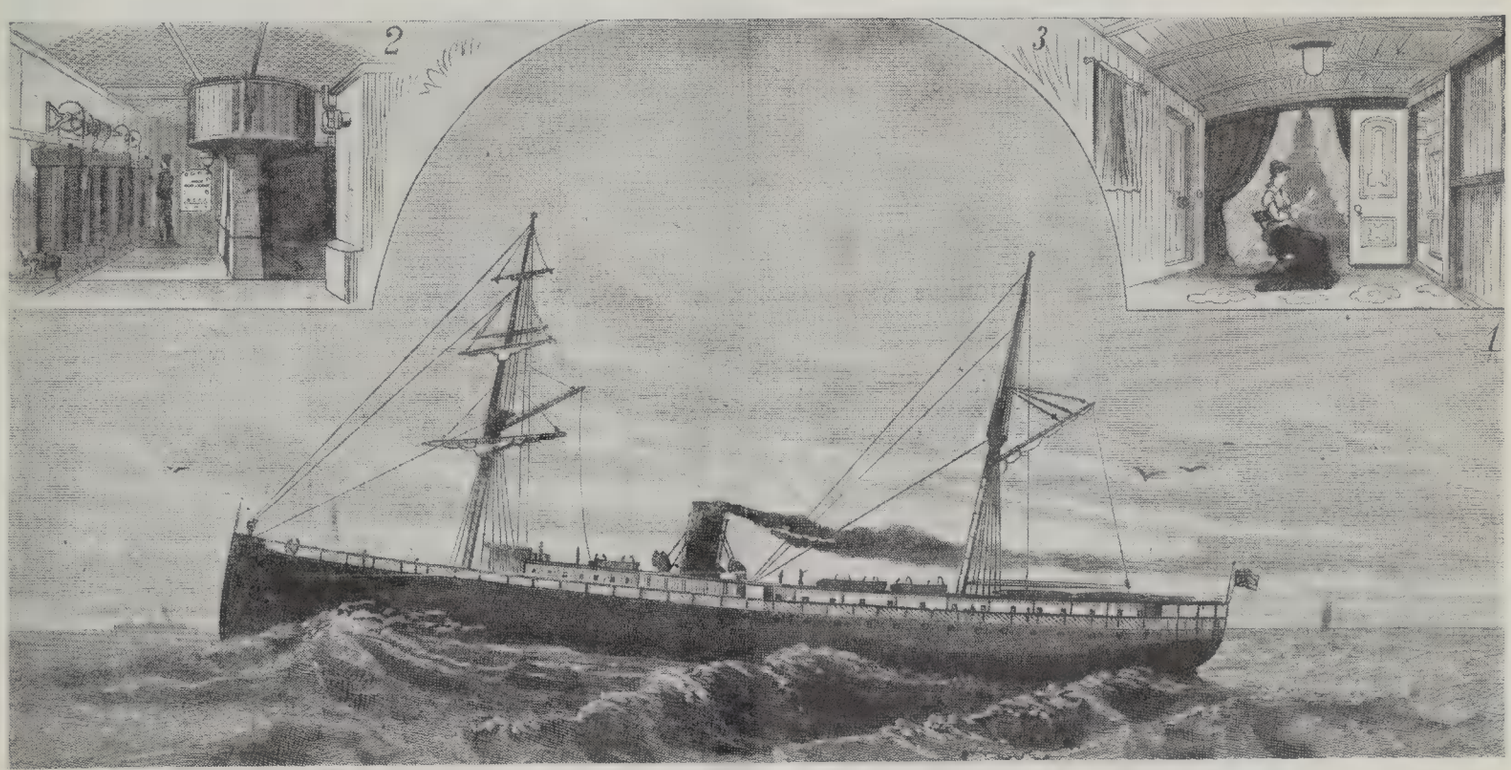
During World War II, Diesel development showed great and impressive advances in efficiency and economy. Most of our landing craft are so equipped, including the famous LST's that performed so notably.

TONNAGE SHRINKS—The interval between 1870 and 1900 was one in which the American merchant marine did not prosper. A combination of circumstances was responsible for a shrinkage of tonnage over the period. As evidence of the decline experienced, in 1870, our total merchant ship tonnage was about 1,448,000. In 1880, this had dropped to about 1,314,000; by 1890, the total tonnage was approximately 928,000; by 1900, it had dropped to about 816,000 tons.

Obviously, in such an era, hull structure and engine and boiler design did not show any startling developments. Most American merchant ships, struggling for existence against the faster, larger, and heavily subsidized foreign flag liners, had extreme difficulty in operating at a profit. Only the innate courage and the high ambition of ship operators and shipyard management kept the American merchant marine alive.

From the Civil War to the turn of the century, progress in marine engineering was slow. Each advancement of new things for strictly land use eventually find themselves on a ship. Electricity today plays a major role in ship operation. Its use was slowly and patiently developed.

Modern merchant and naval vessels incorporate improvements that have been an entire century in the making. As time has passed, American shipping has had many ups and downs. In the background, however, it has, fortunately, been possible to preserve an American shipbuilding industry, so vital to the economic and physical welfare of the nation. The many advances and improvements that today characterize American merchant and naval ships, owes much to the privately operated shipyards of the nation. These yards performed miracles of production in World War I — but their stature grew immeasurably during the period of World War II.



From Scientific American, 1880

The *Columbia,* with dynamo room at 2 and an electrically lighted stateroom at 3

Thanks to enabling legislation, American shipyards have been able to outbuild the rest of the world. In one year (1943) nearly 20,000,000 deadweight tons of merchant ships were built—employment in shipyards was 1,723,000 in 1944.

In normal times, when only one or, at most, a few vessels of a type are under construction at the same time in a shipyard, skilled employees will represent about 50 percent of the total employment. In the war program, however, a very small percentage of those who were employed had all-round shipbuilding experience, or had spent any considerable time in the business. The ability to build ships with less experienced men and inexperienced women arises from the multiple production of ships; that is, the production of a large number of ships of only one type, or of a very limited number of types, in any one shipyard, and it has made possible the adoption of some of the methods of production that are used in the mass-production industries, such as the automotive, sewing machine, farm machinery, and other industries, although the multiple production of two or three hundred ships of a type can hardly compare with the mass-production of 300,000 or more automobiles of one model.

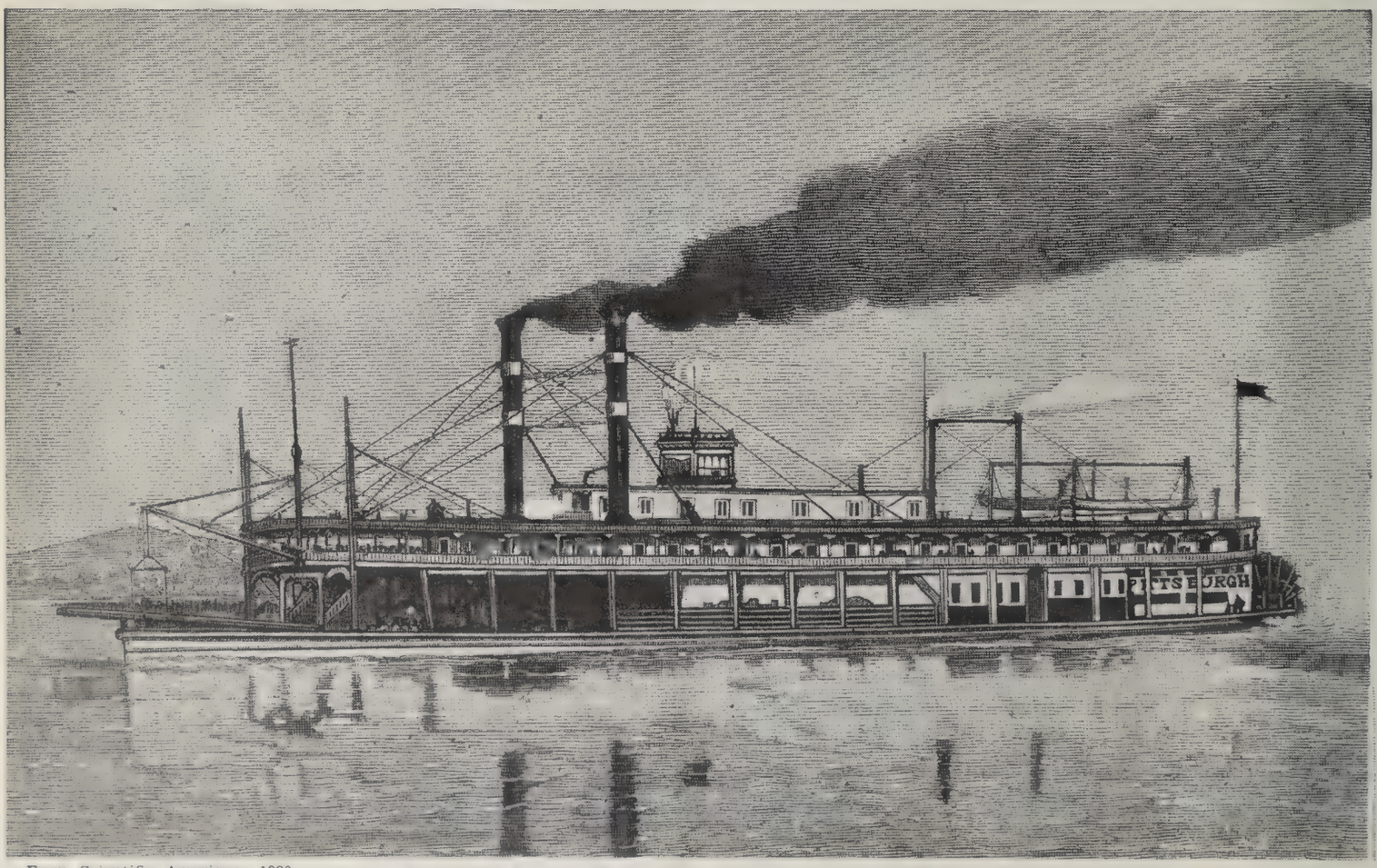
BRAINS AND SKILL—The shipbuilding and shiprepairing industry takes great pride in having met the demands both of the Maritime Commission and the Navy in the call for ships for the war emergency, but it would have been impossible to accomplish this result unless there had existed in the industry, at the outbreak of the war, a group of technical men experienced in the design of ships and a nucleus of skilled mechanics versed in the problems of construction.

As already known, men and women can be trained quickly to perform repeat jobs in the building of ships, but they cannot be trained, except over a long period of years, in the design of ships. Without men experienced and proficient in the art and science of naval architecture and marine engineering, the program of World War II could not have been carried out; it is most fortunate that for a period of ten years such opportunity was afforded to the industry in both the commercial and the naval fields.

One of the most fruitful opportunities for the naval architect and marine engineer resulted from the Merchant Marine Act of 1928, under the provisions of which 31 high-class combination passenger and cargo vessels were built in the United States. These ships were the last word in merchant ship design and equal to the best produced by any other maritime nation in the same period. This opportunity in the merchant field was implemented by a similar opportunity in the naval field. A small volume of construction of naval vessels was maintained in the period following World War I, and from 1933 to the outbreak of World War II there was an accelerated building program giving the naval architect and marine engineer an opportunity for continuous work in the development of designs of the highest classes of naval vessels.

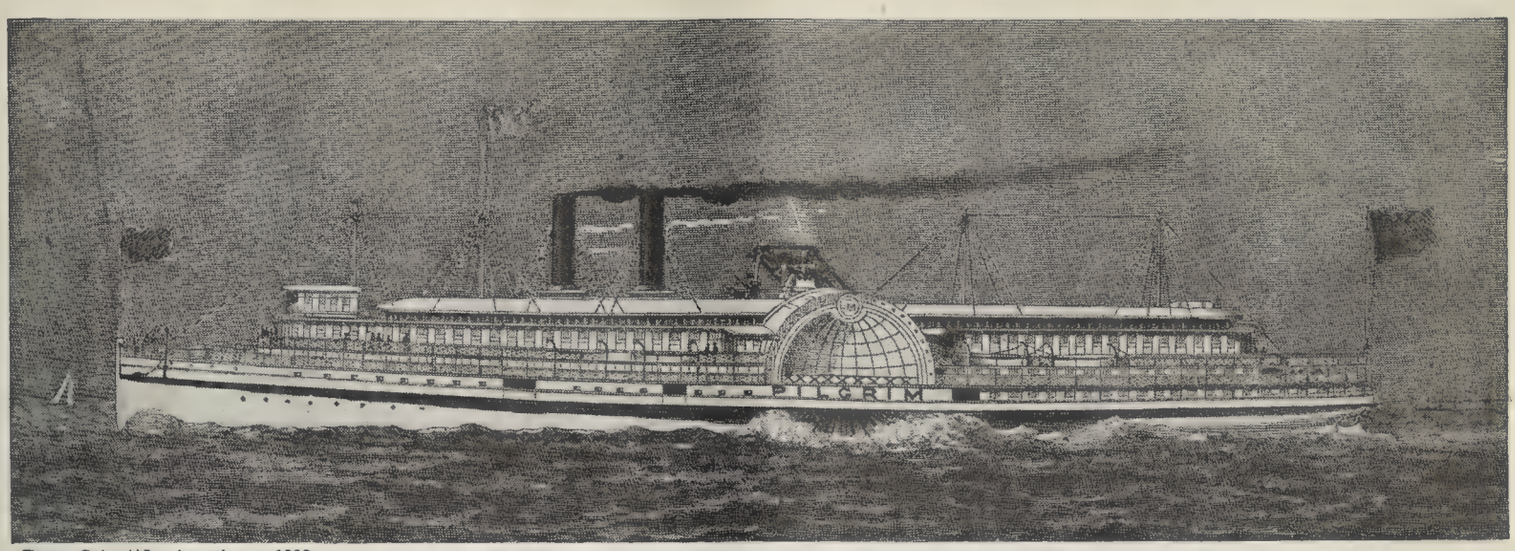
New tasks were imposed on our growing fleet of warships during World War II. This was responsible for certain changes in design to meet new conditions. In the Pacific, for example, it was necessary for our warships to be able to cruise at least 6000 miles without refueling. Our fleet tankers are the largest and fastest, designed to keep pace with a battleship and carry out the refueling while at top speed, a delicate maneuver made possible by American ingenuity.

INVALUABLE LESSONS—Two world wars have taught both American shipbuilding and shipping interests great lessons that should be more generally recognized. First of all, to have a great and useful Merchant Marine, it is necessary to have always a basic and vigorous shipbuilding industry, one that will have personnel and management to plan the best, to be able to meet every possible emergency. If the shipbuilding industry of



From Scientific American, 1880

The light draught steamer *Pittsburgh*, a perfected stern-wheeler



From Scientific American, 1883

The steamer *Pilgrim*, built for the New York and Fall River Line



The *America*, largest and finest passenger liner ever built in the United States

this nation, now the greatest in the world, is permitted, through lack of business, to disintegrate, the economic and physical welfare of America may be endangered. Privately operated shipyards have built a very high percentage of the country's fighting ships—built them fast and well. America can ill-afford to lose the men and the management that has made this possible.

The future of the American Merchant Marine and of the vast and valuable shipbuilding industry of the nation must be viewed with much consideration of all of the facts that are involved. There are so many indeterminates in the balance that any appraisal is virtually a guess.

America ended the war with about 50,000,000 deadweight tons of merchant ships. That is, on paper, the largest merchant marine in the world. However, despite the quantity, the peace-time economic operation of such ships is a manifest impossibility.

POST-WAR—Estimates vary as to the extent of America's post-war merchant marine. One estimate, largely acceptable to many of the interests involved, includes the following: 7,500,000 deadweight tons in foreign trade; 3,800,000 deadweight tons in coastal and intercoastal operation; 3,500,000 deadweight tons on the Great Lakes and 2,500,000 tons on the rivers.

What will happen to the surplus ships? Here again is an important indeterminate. Plans have been advanced for the disposal of the ships, aside from those which will probably be retained by the Navy as auxiliaries. With a Five-Ocean Navy, American naval requirements will be heavy. Before Congress is a Ship Disposal Bill, the status of which is still unsettled. What ships will be sold, to whom they will be sold, and under what terms, are only a few of the factors involved in this all-important piece of legislation. Will the United States follow a plan that has many proponents and sterilize millions of deadweight tons of merchant ships in some fresh-water sanctuary, against a possible emergency? If so, how much tonnage? Will the slow Liberty ships, which will constitute a large proportion of our ship resources, be junked? Or will they be sold to foreign nations?

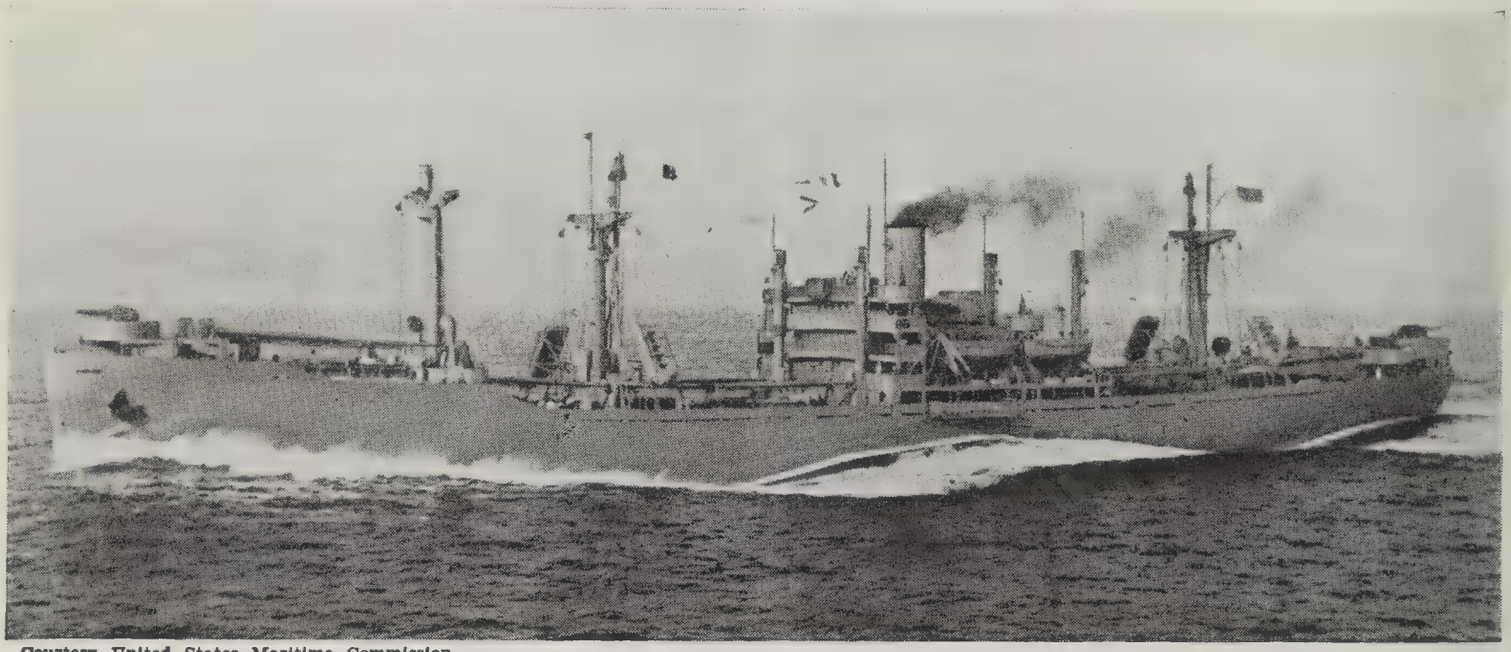
How many privately owned ships that were in war service will be worth reconversion? Certainly, it is doubtful if some former passenger ships can be economically reconverted. Cargo ships, in many instances, can be reconverted, according to some authorities.

What about the foreign flag competition which American merchant ship operators will have to face? It will undoubtedly be severe. It is bound to be alert and very aggressive. To date, fully 26 foreign shipping lines have announced that in the near future they will operate planes over the routes traveled by their ships, offering the public a combined service, under single management. Such services, according to every American survey, will prove popular. They are already in demand. Unless similar privileges are granted to American steamship lines, American air passenger service overseas will be driven straight into the arms of foreign competitors and American passenger lines will suffer serious losses of revenue.

How about the volume of foreign trade? No one knows or can even estimate the volume and flow of future foreign trade. Some claim it will be the greatest America has ever had; others take an opposite view.

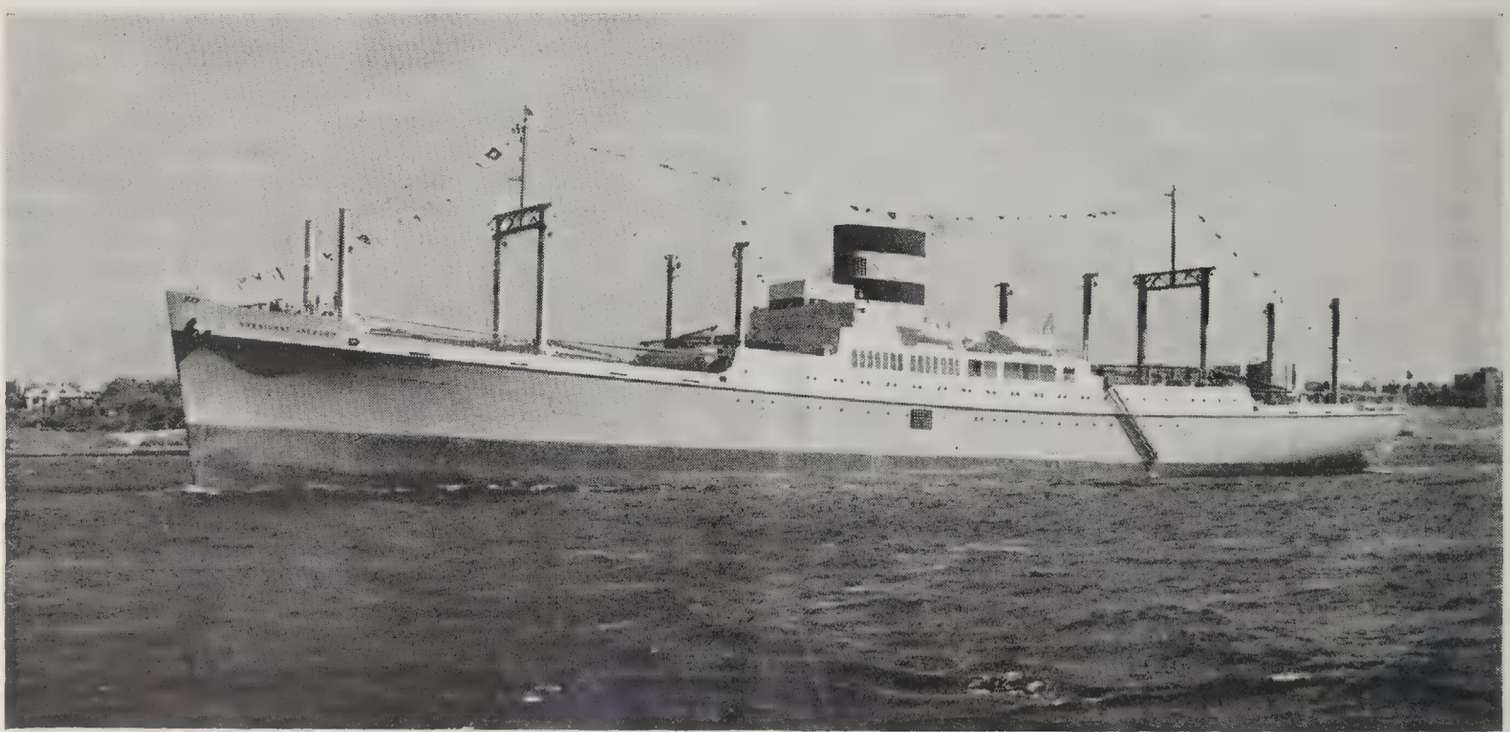
The indeterminates are many and important. American ship operators have to consider all of them, to weigh just how each will influence their particular spheres. Above all, they must be able to operate with a sufficient profit to enable them to replace their ships when the time comes for such action. Big cargo or passenger ships represent a heavy investment. It is an investment the shiplines are willing to make if the future is clearly charted. They want to build new and better ships. No one plans, to the best of this writer's knowledge, to build ships of a size equal to the *Queen Mary* — but several lines are willing to build fine passenger ships of at least 40,000 deadweight tons, providing they have a chance to operate such vessels at a reasonable profit. Many will build passenger ships of 20,000 deadweight tons.

Many of these factors have a distinct urgency about them. Some of them will have to be settled soon — and in the public interest. In the meantime, the only possible prediction in regard to the future of American shipbuilding and the shipping industry, is to say that they have the personnel and the facilities to produce fine, safe, efficient, dependable ships — and they have the trained personnel to man them. What the ships will need will be American passengers and cargo — and the wholehearted support of the nation.



Courtesy United States Maritime Commission

A Victory Ship of World War II



Courtesy United States Maritime Commission

Passenger and cargo ship, *President Jackson*

There are two funny things about Wilmer



The first is Wilmer's getup.

The second is that he doesn't care if he *does* look like a castoff scarecrow.

Because Wilmer's a lot smarter than he looks. While he's making more than he's ever made before—he's doing right by his country. The dough he'd spend for a fancy wardrobe goes right smack into War Bonds . . . and for this Uncle Sam is mighty proud of him.

And Wilmer's doing right by *himself*, too. Because in a few short years he's going to be able to do something he's planned on. He's going to send Wilmer, Jr. to college—and in clothes that won't be any fugitives from a scarecrow, either.

He's going to be able to do it because Uncle Sam is going to give him back a rich hundred bucks for every seventy-five Wilmer's *lending* now.

Naturally, you don't have to look like Wilmer . . . or tramp around in rags . . . to make your country proud of you, and your own future a whole lot more secure.

All you have to do is keep getting those War Bonds—and then forgetting them till they come due. Not bad—that four dollars for every three, and the safest investment in the world!

Why not get an *extra* War Bond today?

BUY ALL THE BONDS YOU CAN
KEEP ALL THE BONDS YOU BUY

SCIENTIFIC AMERICAN

This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council

Plastics Take To Water

Conventional Materials and Methods of Boat Building Are Yielding to the Newer Plastics. Advantages Offered in Boats Big and Small Include Resistance to Corrosion and Fungi, Easy Workability, and High Strengths. Paints, Plywoods, and Laminated Wood all Enter the Picture

To WHAT extent you will be aware of plastics in boats of tomorrow will depend upon whether your interests center on luxury liners, freighters, yachts over 60 feet in length over-all, or smaller boats and cabin cruisers.

If your concern is with the bigger ships, you'll need to delve into the ship's operating mechanisms before you realize what a vital role plastics have come to play. In a battleship, for example, the entire nerve system of the ship is encased in plastics. In a typical battle-wagon, insulating materials made of plastics protect from 850,000 to 1,000,000 feet of wiring.

In large part, the sensational performance of these wires and cables can be attributed to the wedding of electronics with plastics. Without plastics' dielectric qualities, many of today's electronic miracles would be impossible. The principal plastics used in Navy cable are the vinyls and polyethylene. A great portion of this cable is armored; sometimes there are two layers of armor with insulation between. Vinyl resin has generally replaced rubber as insulation material in these applications, particularly in coaxial cable. As for polyethylene—very little can be told at the present time relative to its use in cable. Greatest significance, perhaps, lies in the fact that a comparatively thin layer has high insulation qualities.

In this same electrical field, polystyrene is performing almost unbelievable feats in insulator equipment, and phenolics and phenolic laminates—the old standbys—are much in evidence. There are, too, melamine and glass fabric control panels and switchboards.

PAINTS — Synthetic-resin paints have proved their worth on large and small boats alike. Their most important property for marine use is their exceptional hardness. Synthetic resins in special formulations for wood and metal, for interior and exterior, for topside and bottom, for enamels and varnishes, also offer superior weathering qualities, resistance to alkalis and corrosion, and to moisture and vapor.

Fighting "seabeard" by keeping anti-fouling paint films soft and thus allowing the poisonous ingredients to attack barnacles and other fungi freely is the job of methyl dihydrobitate and tricresyl phosphate plasticizers and cuomarone indene and vinyl resins used as paint extenders and softening resins.

Plasties also play an important part in propeller shaft and rudder bearings. Actual operating experience has demonstrated the advantages of laminates made up of cloth impregnated with phenol-formaldehyde resin for these applications. Tests show that bearings of this material wear three times longer than those made of wood. On one ship, for example, after approximately 70,000 miles travel, the resin bonded composition bearings showed only 0.045 inch wear, with almost no wear on the shaft liner. Lignum vitae bearing, used under precisely the same conditions, showed 3/8 inch wear with the shaft liner worn up to 3/16 inch.



Courtesy Luders Marine Construction Company
Molded plywood for pleasure craft gives greater latitude in hull design and fewer owner maintenance problems

The laminated material also weighs less, even when compared with aluminum, has a lower water absorption, and is easier to install and replace.

Polystyrene, phenolic resins, laminated molded macerated plastics, methacrylate resins, and others, will find even more extensive use in direction finders, electric telegraphs and general power equipment. Fog-penetrating devices, automatic steerers, impeller-type logs, supersonic depth finders and ship-to-shore telephones will make use of both polystyrene and phenolic materials for coil insulators as well as for housings. And there are other plastics units that have seen successful service in big boats.

UNDER 60 FEET—It appears at present that the use of plastics afloat will be in inverse proportion to the size of the boats. Thus, the rosiest field will be in the smallest types —that is, dinghies, top-o'-car boats, outboard motor boats, racing shells, canoes, small sloops, and large rowboats. In the larger types of sailing boats and cabin cruisers, plastics will be used both inside and out to reduce costs and to increase comfort and luxury as well as ease of operation and maximum efficiency.

The anticipated extended use of plastics in smaller boats is tantamount to a minor revolution in boat building. Naval architects and builders have long been considered incurable traditionists. Skilled craftsmen painstakingly have built sea-worthy boats from teak, mahogany, and brass. Persons fortunate enough to own one of these boats have brought it through the

seasons by caulking, sanding, painting, and polishing. Boats have been expensive; demand has, therefore, been small. None dared to challenge tradition.

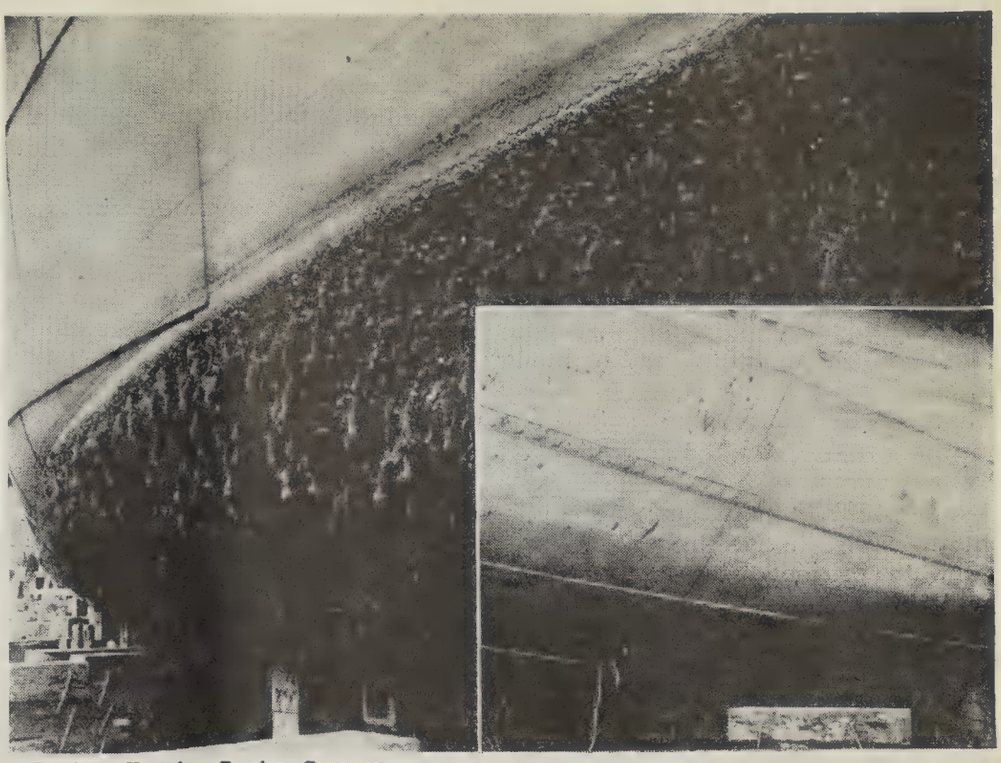
But with Pearl Harbor came the need for PT boats that could take the buffeting of choppy waters at incredible speeds, for life-boats light enough to be airborne and strong enough to drop on heavy seas, for hundreds of coast guard, landing, river crossing, and other small craft to be constructed by the thousands in record-breaking time with no sacrifice of sea-worthiness.

Traditional production techniques were too slow, traditional materials not always suitable. Under the stimulus of this emergency the boat industry began to break with the past, to adopt plastics for hulls, superstructures, and decks.

There are some, of course, who are reluctant to abandon the old methods of boat construction. It is the claim of this group that you can never tell how a material will behave until it has been exposed to a season's wear followed by a winter in storage. They add that it is one thing to test a material for weather exposure or submersion, quite another to put it into actual use where motor vibration, high speeds, heavy seas, and any number of unforeseen conditions might prove it unseaworthy.

The greatest controversy rages around the question of hull materials and construction. The introduction of plastics into the exterior of pleasure boats came with sheet plywood used in such non-structural parts as cabin walls and roofs, for decking, planking, and side-plating. This early plywood, which was bonded with albumin and casein glues, had several shortcomings. But the picture has been altered since the development of phenolic and resorcinal-formaldehyde resins which impart greater strength and resistance to water and fungi.

It is estimated that about 5000 boats of molded hull construction have been produced for the various services during the war. In this process, wood veneers are spread or sprayed with resin, secured over a male form whose outlines conform to the shape of the boat. After this assembly is sealed in a rubber blanket, it is placed in an oven where it is subjected to rigorously controlled heat and pressure to polymerize the resins. After a specified time it is removed from the oven, stripped of the rubber bag, and cooled with a water spray.



Courtesy Hercules Powder Company

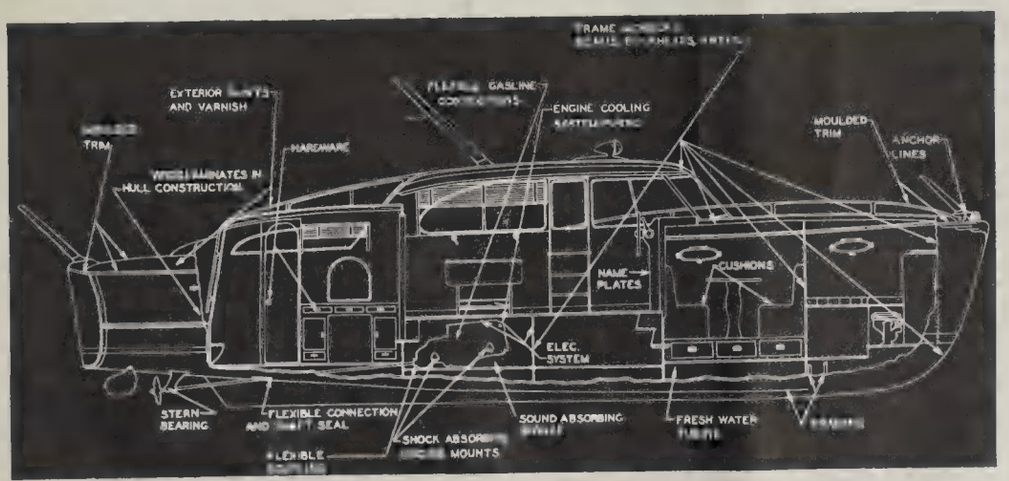
Heavily fouled section of the hull of a steel ship and, inset, another portion of the same hull, treated with anti-fouling paint, after comparable period of exposure

HULL DESIGN—The use of resin-bonded plywood allows considerable latitude in hull design. In the L-16, for example, 25 or which were delivered to racing enthusiasts this last Spring, it was possible to construct a pointed bow and a rounded stern since plywood can be formed into such shapes without wastage of material such as there would be if conventional lumber were used. It is claimed that the stressed skin construction means that the boat is better able to withstand the stresses of choppy waters and high winds. Further, there is a considerable strength-weight gain when plywood is used—plywood being the strongest material for its weight that is known. Plywood has high rot and teredo resistance due to the protection the resin gives the wood fiber, and its use minimizes boat upkeep because the material stays put once it is in place.

An important factor with regard to the use of plastics laminates in pleasure boat hulls is the amazing increase in the strength of plastics moldings when a fiber reinforcement is added. These reinforcing materials include glass cloth, canvas, paper, manila fiber, rope yarn, and needled felt.

Sandwich constructions — with outer canvas covers or mahogany veneers combined with low-density cores of air-filled regenerated cellulose, honeycomb glass fiber construction, or styrene fiber—offer promise that a buoyant structural material is on the way. However, in models which have been developed up to the present time, buoyance compartments—in many cases filled with expansion plastics—have been incorporated as the principal safety factors.

An experimental 17-foot centerboard-type, sloop-rigged sail-boat molded of phenolic impregnated sisal rope fibers shows the refinements of design possible with this material at the same cost, when produced in quantity, as conventional wood hulls. The ease with which the material is formed makes



Courtesy Owens Yacht Company

Some of the possible uses of plastics on a de luxe cabin cruiser

possible any streamlining deemed practical by the designer. A wide-curved bow—a dry type of construction seen in many new boats—is easily produced from the material, as are the combination round-and-vee-bottom hulls.

LAMINATED TIMBERS—When the Navy small-boat program ran into difficulties in procuring enough suitable timbers for its gigantic needs, laminated timbers were adopted. Synthetic glue manufacturers were called upon to formulate resins capable of setting at a lower temperature than the boiling point of water. Such a resin was necessary to prevent excessive loss of moisture from wood in large laminated cross sections during drying, which would tend to weaken the structure. These laminated members permit the use of up to 60 percent low-grade and short-length material in the interior section.

Parts and sections produced to advantage by laminating include aprons, deck beams, binding strakes, booms, cappings, deadwood, frames, horn timbers or counter timbers, keels, keelsoms, knees, risers, shaft logs, side fenders, spars, stems, stern posts, stringers, towposts, transoms, and so on.

Laminated structural timbers have, of course, been in use over 10 years. But prior to the war they were useful only when they could be protected from weather and humidity. Improvement and development of various types of resins made possible laminated parts capable of withstanding the severest kinds of exposure. Properly used, these resins form a joint stronger than the wood itself.

Whatever the future holds, plastics materials will be bound up with boat building. And the prestige that will emanate from their acceptance by conservative boat builders will be felt in many ways. The yachtsman's approval is a goal to work toward.

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MOLDED WOOD

Uses Plastics to Mutual Advantage

Wood has now become so closely allied to plastics that it can be molded in dies under heat and pressure in a way that greatly enhances its natural physical properties and beauty. S. H. A. Young and R. A. M. Palese, of Engineering Associates, in discussing this development, point out that brush backs, knife handles, knobs, and handles of various types which are formed from impregnated and molded solid wood not only possess the beauty inherent in the original wood but are rendered water, acid, alkali, and heat resistant as well. The pieces are also said to possess improved dimensional stability.

The process is relatively simple and the final cost of the article is moderate. A large factor in the low cost is the elimination of the costly finishing necessary on natural wood.



Photos courtesy Engineering Associates

Knife handles made in two parts of molded wood have high strength and hardness, and natural wood beauty

It is also possible in many cases to eliminate as much as 90 percent of the preshaping work. A relatively rough preform develops full mold contour and a high mirror-like finish that is much more than skin deep.

After drying, the wood is placed in a sealed chamber and a vacuum



Preform and finished molded wood knob, with knob section in center

applied and maintained at from 23 to 28 inches for 30 to 60 minutes. After evacuation, resin is admitted to the chamber, and pressure ranging from 150 to 300 pounds per square inch is applied and maintained from one to three hours. Immediately upon removal from the impregnation chamber the treated pieces must be air dried. It has been found that a 12 hour air dry is adequate for most woods, depending, of course, upon the surface area-volume ratio. Then comes oven drying.

The temperatures used in the molding depend upon the type of resin used. Urea, melamine, and phenolics lend themselves readily to the impregnation method. The molding time required for impregnated wood is comparable with that required for equivalent thicknesses of conventional compounds. Mold closing time, however, is somewhat longer for impregnated wood, due to a greater rigidity in the preform. The use of electrostatic preform preheating and of a split molding cycle are two promising possibilities as far as the molding time factor is concerned.

While molded wood falls within the classification of high-impact molding compounds, it is interesting to note that the required molding pressures are far below those required for its conventional counterparts. Pressures in the range of 200 to 1000 pounds per square inch have produced very satisfactory high-strength molded-wood pieces of excellent quality.

Up to the present time this technique has been successfully developed in the laboratories of Engineering Associates for use on such products as knife handles, toy parts, textile items, knobs, pot handles, and other products. While these articles are generally small, there appears to be no reason why molded wood may not be equally successful for much larger units through the use of multiple preforms. This would indicate a potential use in furniture components, such as arm rests, high-chair trays, caster wheels, and table tops.

PLASTICS COATINGS

Applied by Use of Dipping Lacquers

Covering articles such as handles of kitchen utensils and tools, long bars, and the blades of screw drivers with a plastics coating can be quite a problem. This is particularly true when the items do not justify the use of expensive dies which would be needed were they to be covered by injection molding. Again, the shape and character of the pieces may be such that spraying would involve substantial solvent loss.

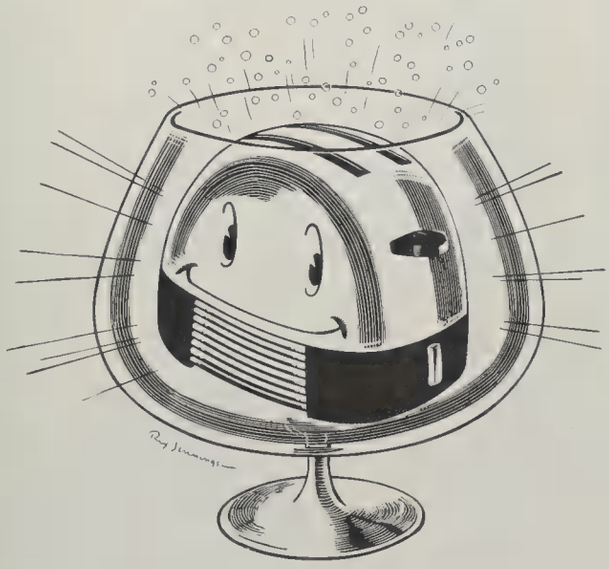
If such is the case the solution may lie in the use of cellulose acetate butyrate (Tenite II) dipping lacquers. These lacquers, which are made by dissolving cellulose acetate butyrate granules and pellets in suitable solvents, produce hard, thick, tough protective coatings varying in thickness from 0.005 to 0.010 inch. Greater thickness of coating is obtained by increasing the solution viscosity or by repeated dipping. The lacquers are available in any color and any degree of opacity. Suitable as a covering for articles molded of cellulose acetate butyrate as well as those molded from certain other types of plastics, they can also be used to coat metal and wood.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

MOLDING COMPOUNDS



DESIGN ENGINEERS ARE TOASTING THE VERSATILITY OF PHENOLIC PLASTICS

Already there are hundreds of new and improved products waiting in readiness for post-victory markets . . . products which have made good use of the versatility of Durez phenolic plastics. Take this eye-appealing toaster, for example. The base and knobs are molded from a Durez phenolic compound which possesses such desirable properties as dielectric strength, brilliant finish, excellent moldability, and resistance to heat and moisture. These characteristics—and many more—are inherent in all of the more than 300 Durez phenolic molding compounds . . . make them the natural starting point when you're looking for the plastic that fits your job.

INDUSTRIAL RESINS



THE NEWEST THING AFLOAT IS THIS MOLDED PLASTIC BOAT

When you stop to consider such properties as extreme toughness, moisture resistance and facile moldability, which Co-Ro-Lite (a combination of sisal fiber and Durez resin) possesses, a sailboat molded from this material seems a logical step forward in plastics progress. This is exactly what has occurred, and the Co-Ro-Lite sailboat has passed every test to date. This new application is but one of many recent developments which use versatile Durez resins.

OIL SOLUBLE RESINS



THE INSIDE STORY ON OUTSIDE PAINTS

Many leading paint manufacturers incorporate Durez phenolic resins in their better quality outside paints—such as house paints—because these remarkable resins speed up the time of set, eliminate water spotting, improve gloss retention, and help prevent mold formation.



HERE'S WHAT YOU'VE BEEN WAITING FOR

Right off the press, the Durez Plastics Primer is a brand new, illustrated booklet about phenolic plastics and is especially designed for quick reading by today's overburdened executive. Not for the technical man who is already familiar with the subject, the Durez Plastics Primer is a brief, simple, crystal-clear digest filled with basic facts covering the part the phenolics play in the over all plastics picture. Clip the attached coupon and send for your free copy. Absolutely no obligation, of course.

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PLASTICS THAT FIT THE JOB

Export Packaging Is Different

Attention to Important Details Assures that Instruments, Machinery, and so on, Will Reach Their Destinations Undamaged, Mechanically or by Corrosion. Product Protection for Many Items is More Necessary Today than Ever Before. Many Problems Must be Studied and Solved

A MANUFACTURER of fine precision instruments recently shipped a dozen of them to a tropical country. Soon after their arrival he received a number of complaints from the customer. Polished steel surfaces had corroded enroute, electrical insulation was failing, supersensitive bearings were sticking instead of turning at the slightest application of power. To save time and trouble he had them all returned for full credit.

This incident started a complete restudy of that manufacturer's export packaging and anti-corrosion protective methods. Similar studies must be made by thousands of manufacturers if our country is to do the volume of foreign business which nearly everybody anticipates.

First of all was the corrosion problem. The rust preventive methods which were perfectly adequate for shipping within the United States would not do at all for foreign markets. The extreme changes of temperature which the packages might meet while being shipped abroad—all the way from far below zero in a high flying airplane to more than 120 degrees above zero in the hold of a river steamer—would defeat the rust preventives which had been used for shipments to local markets.

A more effective type of corrosion preventive might solve this. But there was another problem. The electrical troubles had been caused largely by using an improper solvent to clean the corrosion-preventing compound from the steel and letting the solvent spill onto electric wiring and insulation. It was plain that the new corrosion preventive would have to be a type which could be wiped off without the use of solvents.

There also was the problem of where the corroding moisture had come from. The exterior of the package seemed to be adequately moisture resistant. Some moisture might have been exuded from the packaging materials, since the fiberboard and paper commonly used in packaging depend upon high moisture content for strength and will give off moisture at certain temperatures. But no one explanation seemed to furnish the complete answer.

The bearings had been damaged partly by the solvent, partly by moisture, and partly by the fact that the packaging materials and the structural designs of the members which braced the instruments within the packages were inadequate for the rough handling and other shocks of export shipping.



Courtesy Western Electric Company

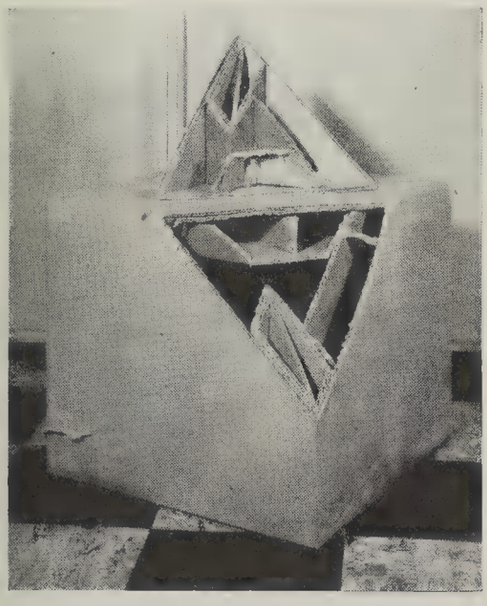
Heat sealing and exhausting of excess air from an export package

PACKAGE ATTACKED—The first attack upon this problem was directed at the package itself. A moisture-proof, heat-sealed, envelope was designed to enclose the entire instrument. With this, any moisture which, due to shocks that might rupture or weaken the moisture-proof barrier at the outside of the package, penetrated into the interior, would have to pass a second barrier before reaching the instrument itself. The inner envelope would protect against moisture exuded from all but the small quantity of cushioning materials which had to be within it.

The structural bracing within the package was improved in design. Formaldehyde-urea impregnated corrugated fiberboard was used for the bracing—a material which is stiffer, more moisture- and

wear-resistant than the kraft boards used for domestic shipping. This assured that even under severe handling the braces within the package would not break down, with resultant damage to the instrument.

Studies were made of the possibility that the inner envelope might be so chafed by the structural bracing which would rub against it that it would lose its protective properties. It was found that at the highest temperatures which the package might reach the air pressure within that envelope would increase to the point where the envelope was stretched or expanded outward toward the bracing, thus increasing the chafing danger. A vacuum line was rigged to remove the excess air from the envelope, with the envelope immediately being heat sealed to prevent re-entrance of air. No attempt was made



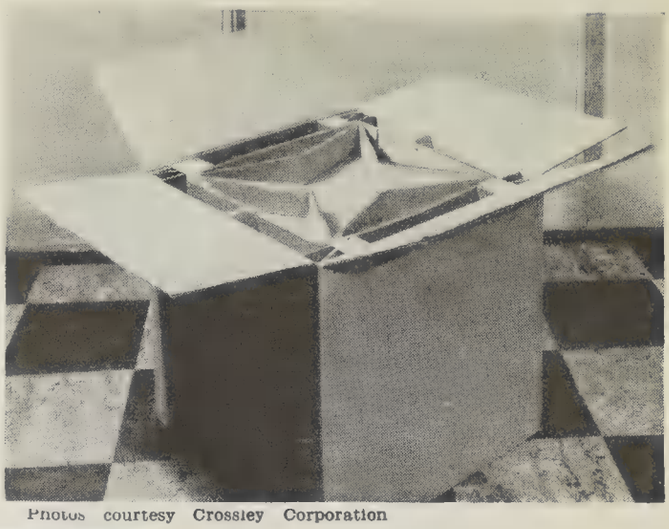
to create a vacuum; the object being only to collapse the envelope about the instrument so that the drawn-in portions would be available as expansion areas when the remaining air became heated.

To reduce still further the possibilities of chafing, flat sheets of corrugated fiber board were placed between the bracing members and the inner envelope. This made the entire package a "box within a box," a floating construction which would be shock absorbing to a high degree.

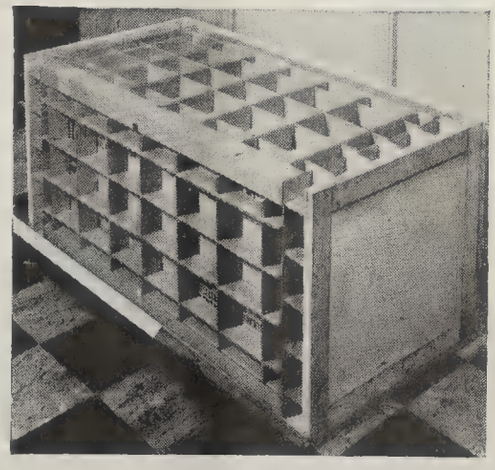
With this arrangement the outer walls of the package could actually be punctured by rough handling and the instrument would still have a high degree of protection.

The inner box then was redesigned so it also could be sealed against moisture, providing a third barrier. Within this would be placed activated silica gel which would absorb any moisture that might be exuded by the packaging materials themselves. The package then had

Right: Bracing members of this strong package lift out as a unit. Lower left: Interior package bracing needs careful structural design. Below: One of the last packaging operations before the final sealing



Photos courtesy Crossley Corporation



four-way moisture protection—outer wall, inner wall, silica gel, and inner envelope.

RUST PREVENTION—A new rust preventive compound was adopted for the fine steel surfaces—one which required only to be wiped off with a clean rag and which would be an excellent lubricant for the bearings if it got into them. This compound, although light and thin, was high in its water and moisture displacing abilities. If water actually got to the steel, the compound would tend to lift it off and let it flow away. And although the new preventive was not so completely protective as the old, harder, and heavier one, the instrument maker knew that any handling of the package which was rough enough to puncture the inner envelope and let large amounts of water get at the instrument would be likely to do enough mechanical damage to ruin the instrument so that further damage by rusting would be of no consequence.

The electrical parts were protected by a compound which is resistant to oils, solvents, and moisture, and which would continue to protect through long periods of service. Heat would only harden this material. Similar materials give long-time protection to the exteriors of spark plugs and other electrical parts even when in service on airplane engines.

The completed package received the usual drop tests to observe the effects of rough handling. But the company wanted to be sure that a machette-wielding laborer, left to his own devices to open the package, would do no damage.

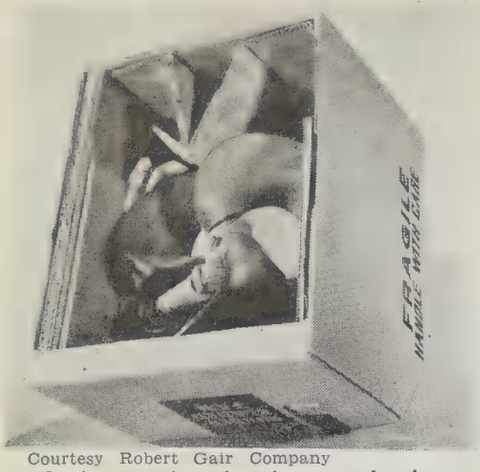
The top end was marked plainly on the package exterior, and in the language of the country to which shipment was to be made. There was more than three inches of bracing material between the outer box and the inner one, and this would keep any ordinary cutting tool from penetrating the inner box while the outer one was being opened.

The bracing members nearest the cover were arranged so that sections of them would lift out as a unit. Before this was done there was a temptation for the laborer to cut through them with chopping strokes of his machette, and he easily could cut clear through to the instrument and do damage.

The fact that the inner box was to be lifted out as a unit, rather than being torn open while still surrounded by bracing members, was made clear by printed labels which included cartoon drawings of how to lift out and open it. To emphasize the point, and to provide still greater structural strength, the inner box was provided with crossing bands of steel strapping. The directions showed that the inner box was to be placed on a firm and level base, the steel bands cut, the sealing tape torn away at the corners and the sides allowed to fall down. After that the inner envelope could be torn away and the instrument mounted for use.

REDUCED COSTS—Next on the planning schedule was to turn the corrosion protective applications and the packaging into a progressive or "production line" operation to reduce costs.

Every steel part had to be cleaned thoroughly. Thorough corrosion pro-



Courtesy Robert Gair Company

Package and product brace each other

tection is very nearly impossible if there is foreign matter of any kind on the material to be protected. Any finger prints which might be on the materials had to be cleaned off or neutralized, since perspiration is often highly corrosive. And for greatest economy and safety all corrosion protective operations on steel parts had to be performed in an air conditioned, dust-proof room.

There are wide differences in the drying or "setting up" time periods required by various corrosion-resisting compounds. A compound was found for the bright steel parts which required no more setting up time than was needed to drain off the excess after the parts had been dipped in it. This was considerably less time than had been needed for the compound previously in use. It reduced floor space needed for draining and drying the parts, equipment needed for hanging them while they dried, and other costs.

Parts were handled with steel hooks and other metallic devices while being dipped, drained, and dried. With the previous compound these had left bare metal spots which had to be "touched up" by hand. The new compound spread over the bare spots after being released from the holding devices so this cost was eliminated.

The compound used on the electrical parts required eight hours to set up thoroughly, but would form a dust-proof outer skin within a few minutes of application. This, therefore, was applied in a separate room, with the finished electrical assemblies being pushed along a gravity conveyor to an ordinary storage room where they could stand and dry.

Final assembly required taking the finished steel assemblies and the finished electrical ones to an air conditioned room which was kept at 65 degrees, Fahrenheit, so there would be no tendency for the operators to perspire. All of these operators wore clean white gloves. And as a final precaution a perspiration corrosion inhibitor was included in the protective compound for the steel parts.

The instruments were sealed within the inner envelopes and again sealed and strapped within the inner boxes before they left this room, these operations being performed immediately after final assembling and final inspecting to make sure that no metal surfaces had been left unprotected. Storage was in these boxes, the bracing members and outer boxes not being put on until final shipment—a method which saved shelf space.

Companies facing such export packaging problems as these can draw to some extent upon Army and Navy war experiences in shipping of materials to battle areas. But there are two important ways in which the civilian requirements differ from the military. First, commercial goods will not have to meet such severe conditions as military. Second, commercial companies cannot depend upon the openers of packages to be specially trained, specially selected men who are accustomed to following instructions.

Export business will be a larger factor in the future than it ever has been in the past. And thousands of manufacturers will have to make intensive studies of export packaging before they can compete for this business.

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MACHINING PLASTICS

Requires Application of Special Techniques

A HIGH percentage of plastics are made in sheet, rod, or tube forms and must be machined to produce finished articles, and molded plastics pieces often require secondary machining operations such as tapping.

In machining operations, provision must be made for the thermal expansion of the material. Plastics are frequently high in coefficient of thermal expansion, and the methods of removing heat by copious flows of cutting oils, as practiced in metal working, may not be suitable for them. Female centers are preferred to male ones and tolerances on machined surfaces must allow for shrinkage on cooling.

Chip pressures and temperatures generally are not so high as those of metal working. Adequate hardness of the tool therefore can be more important than temperature endurance. When the plastics contain extremely abrasive materials, such as glass reinforcements, the very hardest tool materials (diamonds, cintered carbides, cobalt alloys) may be required.

The pressures which the tools exert against the material may need to be applied in the directions of the greatest volume of the material, or in such directions as to tend to press sheets of laminated plastics together rather than tear them apart. Unlike most metals, many plastics are stronger in some planes than in others (section thickness for section thickness) and so far as is practical the greatest tool pressures should be in the direction of the greatest strengths.

Chip scavenging can be a problem. The chips of many plastics tend to pack rather than to flow freely along the scavenging passages of the tools. The use of cutting oils at ordinary feeding pressures may only increase this packing tendency. Compressed-air blasts can help, and so can streams of cutting oil blasted at high pressure from beneath the tool points. Scavenging passages should be deep and smooth.

WIRING WITH INK

Possible for Low-Priced Radio Sets

IT HAS long been known that various materials could be mixed with printers' ink and then printed on ordinary materials for various effects. Among the common uses are the printing of abrasive mixed inks to produce abrasive paper surfaces which at least are good for match scratching, and the printing of metallic inks to produce striking effects.

Latest in this field is the printing of metallic inks in diagrams which will act as electrical conduction circuits in low priced portable radios.

The base stock upon which the printing is done must be stiff and strong enough so it will not bend or break to rupture the printed lines and thus break the circuit. It also must be non-hygroscopic enough so that it will not absorb enough moisture on humid days to cause short circuits. And it must be dimensionally stable so it will not expand and contract enough under ordinary temperature changes to cause trouble.

All of these properties are to be had in treated cardboards and other base stocks which in peace-time sell for quite low prices. As a result, the printed metallic electrical circuit is on its way. But the developers of it are sitting on the lid; they are keeping its present stage of development secret.

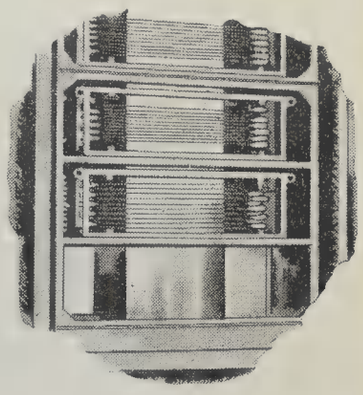
he started something that will never stop

23 YEARS AGO a Westinghouse research engineer started something that was destined to have a profound effect upon the lives of all of us . . . and upon generations yet unborn.
That *something* was radio *broadcasting*.



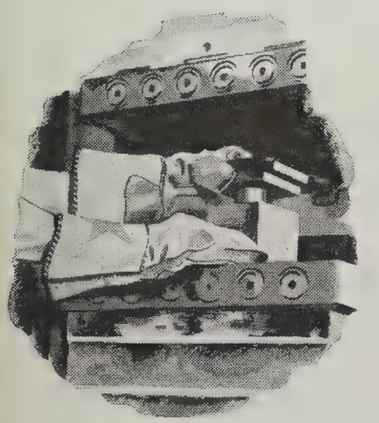
Radio broadcasting was born

on November 2, 1920, when the Presidential Election returns were broadcast from the tiny radio station, KDKA—built by Dr. Frank Conrad at the Westinghouse plant in East Pittsburgh, Pa. It was the first *scheduled radio broadcast* in history . . . the forerunner of a world-wide network that would eventually carry enlightenment and entertainment to the far corners of the earth.



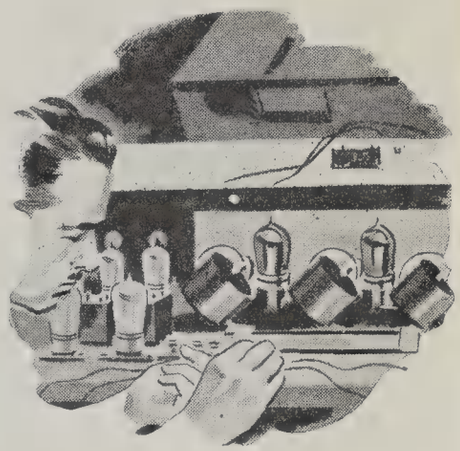
Another "first"

by Westinghouse was the use of radio waves to fuse a mirror-like finish on dull electrolytic tin plate. High-frequency induction heating now helps make *one pound* of war-scarce tin do the work of *three*.



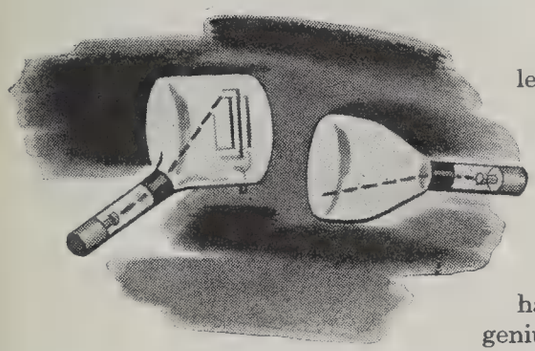
Dielectric death

. . . administered to weevils in grain elevators . . . is another example of the ingenuity of Westinghouse high-frequency engineers. Westinghouse dielectric heating equipment is today speeding the bonding of plywood and curing of plastics and synthetic rubber.



Frequency modulation

was pioneered by Westinghouse scientists as far back as 1920. At that early time they experimented with high frequencies that led the way to the static-free, crystal-clear FM we know today.



Television

has become a reality because of the genius of Westinghouse micro-wave experts, who developed the forerunner of the Iconoscope in 1923 and the Kinescope in 1929. These devices banished forever cumbersome scanning discs.



Research in microwaves

never stops at Westinghouse. Research, begun 20 years ago, resulted in the key electronic tube for the *first* long range Radar equipment. Other secret devices, born of war in the Westinghouse Research Laboratories, will contribute to a better, brighter peace-time world.

Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Tune in: JOHN CHARLES THOMAS—Sunday, 2:30 pm, EWT, NBC ■ TED MALONE—Monday through Friday, 11:45 am, EWT, American Network

Ship Welding Wins

Despite Early Troubles, Welding Techniques Have Advanced to a Point Where they Will be Used in Many New Designs. Locked-up Welding Stresses, Usually Caused by Incorrect Procedures, Can Exert Explosive Rupturing Force. Now Such Stresses Can be Controlled

RIGHT this minute the engineering department of many a shipbuilding company is working out the final details of its post-war all-welded steel ships. This is in the face of the fact that three short years ago welded steel ships were splitting their plates in mysterious ways and some ships were splitting apart and breaking in two.

Ships now on the drafting boards have contours more beautiful than any pre-war designer ever thought practical for production by shipbuilding methods. They will be lighter, faster, get more speed from the same power, be more seaworthy. They will roll less, pitch less, have plenty of room for air conditioning plants for the comfort of passengers and the protection of cargo. There will be plenty of materials-handling equipment aboard; cargo will go into and out of holds much more rapidly, thus cutting down the time during which ships are tied up in ports and increasing their sailing and earning days per year.

None of these features — and plenty of others — is in the dream stage. All of them are solidly practical, made so by the ability of welding to fabricate strong and lightweight structures. And the way in which ship welding licked its early problems is one of the sagas of industry.

Right from the start of their production in a big way for war service, all-welded ships had some amazing successes to go along with their failures. There was, for example, the "Anne Hutchinson." This Liberty ship was torpedoed and broke in two. Both ends continued afloat until the after section was sunk in a storm. The forward end was torpedoed a second time, the engine being knocked loose and moved ten feet from its base by the explosion. In spite of that, the forward end continued to be buoyant and was towed safely to port. Dozens of other ships made voyage after voyage, their only troubles being an occasional ruptured plate.

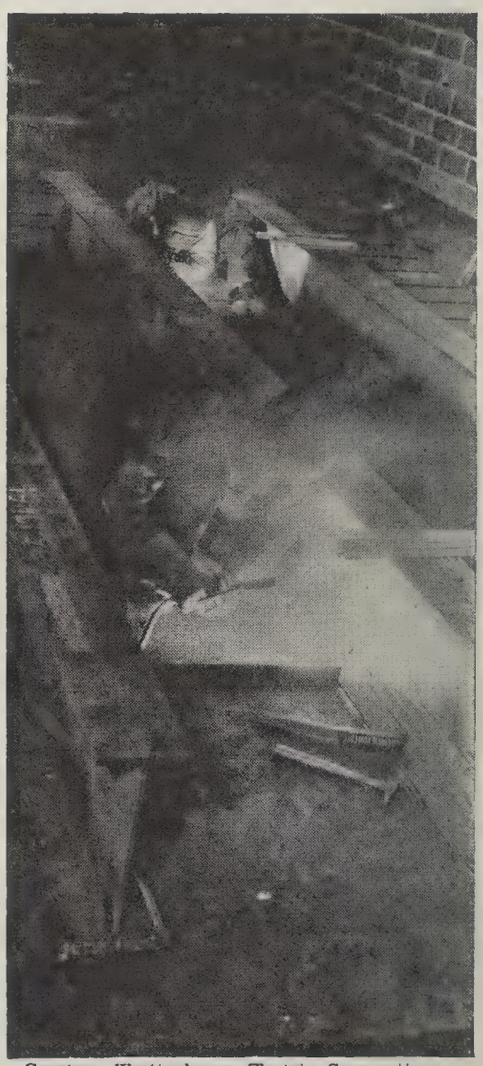
Search for the cause of the ruptured plates quickly found it in locked-up or residual stresses. And right here the shipbuilding engineers had to face a plain metallurgical fact. Locked-up stresses exist in any steel which is heated to a red temperature or hotter and then allowed to cool. There are residual stresses in any steel which is cast, hot rolled, or welded. They cause any steel which is heated and then cooled to change its shape. As a laboratory demonstration a cube of steel which is heated and cooled enough times will ultimately become a sphere.

STRESS RELIEF — Most of such stresses can be relieved by annealing. But there is no way to anneal the thousand-foot-long hull of an all-welded ship. And the locked-up stresses caused by the heating and cooling of welding were so strong in some ship plates that when they concentrated in small areas of the plates they sometimes acted with the speeds of explosions. Plate steels which, under the slow actions of tensile testing machines would stretch several inches before they broke, would fracture as cleanly as cast iron when these stresses ruptured them.

Observation of many ruptured plates disclosed an important fact. There almost always was a "detonator," a starting point which weakened a definite area of the plate, invited the stresses to concentrate there, and instigated the rupture.

A square-foot by square-foot search of ships'. hulls and other members was made to find and eliminate these detonators. Some of them were sharp points or re-entrant angles where plate met plate—ship design practices which had been quite all right for riveted ships. Others, strange to say, were caused by the very zeal of sub-contractors who had forgotten that the thickness of a weld is governed by the thinner of the two metal pieces to be joined. These contractors were putting on too thick welds, thus subjecting the thinner pieces to far greater heat stresses than were necessary, and their sole purpose in doing so was to put in plenty of welding rod—that is, plenty of joint metal—for the sake of the war effort.

Re-design went hand in hand with changes of methods. In some cases

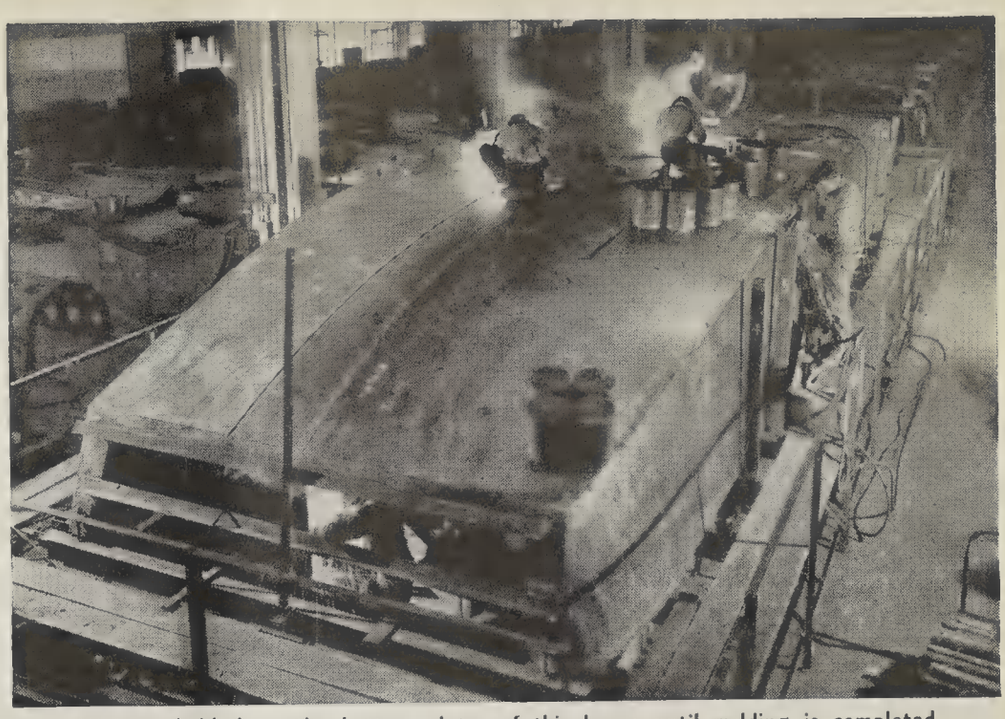


Courtesy Westinghouse Electric Corporation

Arc welders fabricating a heavy fixture used in assembling marine turbines

a new design of a section would eliminate the joining of thick sections to thin ones. In others the welders and the sub-contractors had to be instructed.

Fitting methods were found to be faulty. The engineers had to rediscover the old truth that welding is only one of a series of operations which results in a welded structure. Plates would fail to meet, and the welders would saddle-weld to cover the crevices, thus practically guaranteeing that trouble would ensue. Bulkheads would be made slightly small and would be moved from their fair lines (proper positions) to take advantage of the curvature of the hull so that metal would meet metal and welding could be done. This put the bracing of the hull in positions and at angles not intended by the ship designers.



Weights hold down the bottom plates of this barge until welding is completed

TROUBLES ELIMINATED — Limits and tolerances on all parts were then tightened. Mechanical controls were applied to flame cutting of plates in preparation for welding. Trouble after trouble was eliminated.

Some of the worst problems were found in the welding itself. Overwelding to make sure of strength made sure of weakness instead. Bad spots in welds were burned out and rewelded, thus vastly increasing the application of heat to small areas and setting up additional stresses. Excess heat was applied to finish-off welds, make them look better. This also put unnecessary locked-up stresses into the plates. The idea had to be sold to the welders that the only good weld is the one which is done right the first time. With new welders being trained at rates as high as 700 a month for a single shipyard, this selling had its problems.

Such improvements prevented many a ruptured plate, kept many a ship out of dry dock. Rupturings bad enough to sink a ship, unless caused by enemy action, became non-existent — there never had been many of them. But even so, the corrective measures had not gone far enough.

Methods engineering had to be applied. Management or staff engineers, working exactly as they would in large factories, had to take from the welder and his foreman all authority to decide what should be welded, at what time, and in what sequence.

The sequence in which welding operations are performed is highly important. If the operations proceed from the middle of the structure toward its edges or open ends, then the locked-up stresses can be kept to their fewest and lightest. Two or more operations can be timed so that the welders work together in team play to draw most of the shrink stresses into a single direction instead of causing them to oppose and multiply each other. Problems like these had to be worked out by engineers.

The engineering, too, had its limitations. One of them was the sizes of individual welded assemblies. After an assembly gets to be just so big and complex it is hard to plan sequences of weldings which will keep down the locked-up stresses, harder still to handle or "position" it so that the most rapid welding techniques can be used. This is the main reason why ships are built of welded sections which later on are welded together.

Laying out the individual assemblies, laying down the methods by which they were to be welded together into sections and the sections in turn into entire hulls and superstructures, was an engineering design problem. A single ship might be made up of more than 500 welded assemblies which were made into over 50 sections.

The process was hard for any one man to visualize. But every executive from top-flight engineers to foremen had to see just how the ship would go together and just what his part of the job would be.

DRAWINGS AND MODELS—Some companies solved this problem with isometric drawings. Others made plastics scale models. Lofting to scale, as is done by aircraft companies, found its way into the shipyards too. But in every case there were clear lines and figures showing every operation. And as so often is the case with industrial products, the best liked device was the scale model which the men could take apart and put together with their hands.

Meetings of design engineers, production engineers, and foremen were held to discuss the drawings and models. There was many a suggestion. Here a change could be made to eliminate a weld in a tight corner, there a joint which was nearly inaccessible for welding could be made easy to get at.

Production methods were worked out just as carefully. Flat horizontal or "down position" welding is by far the fastest and easiest to do, therefore it is likely to be done best and to result in the fewest locked-up stresses. By using materials handling devices, welding positioners, jigs, and skids, some yards were able to do nearly 80 percent of their work in this position.

Automatic or "machine" welding was substituted for hand welding wherever possible. There were two reasons for this. One was the saving of time; the machine process can be seven times as fast as manual welding on butt-welding operations, two to three times as fast on fillet welding. The other reason is that machine welding is more subject to exact control. With it the human errors which lead to locked-up stresses could be reduced.

Experience showed that machine welding did not require the work to be completely level. Provided the weld progressed up hill so that the puddle flowed away from the arc the work could be as much as eight degrees out of level in the direction of the welding and considerably more than that in other directions. This increased the number of machine-welding applications.

Devices such as magnetic chucks to hold work, chill bars, electronic



Courtesy General Electric Company

The *African Comet*, first all-welded American passenger-cargo ship

controls, and so on increased the automatic control of welding and with it the certainty that the locked-up stress problem would be greatly reduced.

WELDING RODS—Experiments with larger-sized welding rods brought out a new technique which still is being developed. The old theory was that the smaller the rod the less the heat and therefore the less the stresses. But with larger rods the welding is faster and the heat is applied to any one point for a shorter time. The result of the higher welding speed is that extremely high temperature is applied to a far smaller area of the plate. There is less buckling, less warping, less changing of the size and shape of the plate, and therefore less residual stress.

With all of these improved methods the all-welded steel ship still is full of locked-up stresses. But these stresses are small enough so they do no damage unless someone adds to them or throws them out of balance.

And here is the final problem: There is inevitably somebody wanting to weld something to the plates of a completed ship, or cut something off with a gas flame, or make a welded repair. The brand new thermal stresses thus introduced often are enough to set loose the stresses of welding and warp or rupture a plate. Such work has to be done by skilled men, men who know the forces with which they are dealing and can follow safe practices.

In spite of its problems the all-welded steel ship has reached the point where in many respects it surpasses anything else that ever has floated. Shipbuilders have their newest designs all ready. And they know that with welding they can make their new ideas work.

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BEARING ALLOY

Backed Up by Steel Strip

DURING the last few years the Ford Motor Company has developed and used a new type of engine bearing able to stand up under heavy loads at high speed. In road tests, some of the new bearings and crankshaft journals showed no measurable wear at the end of 50,000 miles, according to *Automotive and Aviation Industries*.

The bearing material is called "tri-alloy" and contains 35 to 40 percent lead, 4½ percent silver, and the remainder copper. Bearings are made by a continuous process in which hot-rolled steel strip is pulled through a coating bath of the molten alloy and thence through a die that leaves exactly the right amount of bearing metal on the strip.

MILLING CUTTERS

Economically Made by Precision Casting

ONE of the fast-developing uses of the lost-wax precision casting method is for making high-speed steel milling cutters.

Milling cutters of such hard steel are difficult and expensive to make, either by direct machining or by the inserted blade method. The precision casting technique has saved one automotive manufacturer thousands of dollars in the manufacture of thousands of milling cutters.

The precision-cast cutters are made to very close tolerances and require no finishing, except sharpening of the cutting edges.

SUTURES

Made of Stainless Steel Exhibit Desirable Qualities

TO THE list of metals used as "human hardware"—to mend and repair man's fragile bones and joints—has been added stainless steel sutures, made of a specially heat-treated chromium-nickel stainless steel called "Surgaloy" by its developers, the Davis and Geck Laboratories, Inc., according to Vanadium Corporation of America.

The stainless steel wire has been used in sizes down to 0.003 inches in diameter and is non-absorbable, pliable, high in tensile strength, kink-proof, and non-breakable in this service, and can be easily tied into knots. It is also non-magnetic, corrosion resistant, electro-passive in body fluids, and well tolerated by body tissues. It can be exposed to diathermy and X-rays.

The stainless steel sutures have been found ideal in surgery of nerves, tendons, thyroid glands, and hernia, in plastic surgery, in bond surgery, and as dermal and tendon sutures.

VALVE FACING

Improved by Use of New Alloy

HIGHER-COMPRESSION engines, taking advantage of new fuels, have created new problems for valves and valve-facing materials. Today's and tomorrow's materials must be highly resistant to elevated temperatures, and especially to deformation and corrosion at operating temperatures.

For this heavy-duty service the Wilcox-Rich Division of Eaton Manufacturing Company has developed a new valve-facing alloy containing chromium, nickel, tungsten, and cobalt. The alloy is reported to be superior in corrosion resistance to the cutting-tool alloys frequently used, although somewhat inferior to nickel-chromium facing alloy. In resistance to deformation in the "red zone" above 1000 degrees, Fahrenheit, the new alloy (called "Eatonite") is described as superior to other materials so far tested.

Engine tests on heavy-duty L-head automotive engines and high-output supercharged aircraft engines show the new material to be the best yet developed for such use.

Can the life of steel products really be increased by 4 to 1?

"SOUNDS impossible," you say? Well, before Pearl Harbor you would have been right.

Then something happened. A startling discovery that means you may soon be able to buy washing machines, automobiles, hardware, *many* important metal items that can outlast any you've ever owned before by 4 to 1!

The discovery is CORRONIZING, a miraculous new weapon against corrosion and rust. Invented by scientists of the Standard Steel Spring Company, CORRONIZING is a new alloy "armor" that *outlasts other rust-resisting coatings for steel.*

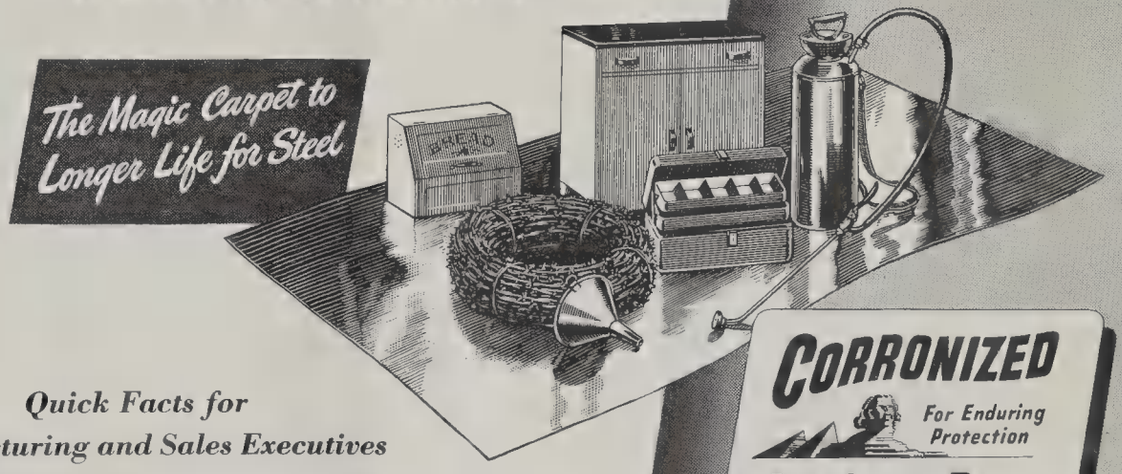
This is no mere claim. It has been proved in the war, on land and sea in every kind of climate. Progressive manufacturers and retailers will soon be able to bring you products made with "Corronized" steel. Motor car makers—always a step ahead—may be among the first to offer this sensational advantage.

So watch for the wonderful new products that will be made with "Corronized" steel. They can defy rust . . . keep their beauty and safety years longer . . . increase the service you get for your money as much as 4 to 1.

Standard Steel Spring Co.

ORIGINATORS OF

CORRONIZING



Quick Facts for Manufacturing and Sales Executives

Do not confuse CORRONIZING with other metal coatings. This patented process provides a permanent alloy "armor" with 5 layers of defense against corrosion! It becomes part of the steel base . . . can be worked in any manner. Permits using lighter materials by prolonging steel's period of greatest strength. Write for samples and complete information.

STANDARD STEEL SPRING COMPANY
CORAOPOLIS, PENNSYLVANIA

Electronics Afloat

Radio Adds to Safety at Sea in Many Ways. Radio Buoys Mark Channels, Radar is in the Offing, Radio-Telephones Help to Conquer Weather Hazards, Automatic Alarms Pick Up Distress Signals and Warn of Fire. Other Marine Uses of Electronics are in Being or Projected

By JOHN MARKUS
Associate Editor, *Electronics*

FIRST action entry in the diary of maritime radio was made during the early morning hours of March 3, 1899, when the *East Goodwin* lightship, off the shore of England, was rammed by the S. S. *R. F. Matthews*. Before this, a ship going to sea was alone from the time her masts sank below the horizon until she entered her next port or perchance sighted another ship—alone with a fire, alone with the hull stove in after running into shoals, alone when the wind blew a hurricane and mountain-high waves tossed her around like a match in a whirlpool. But on this history-making day tugs were on their way in a few minutes to tow the damaged ship out of danger, because four months earlier Guglielmo Marconi had equipped the English lightship with wireless equipment and in her distress she had flashed her message of appeal to South Foreland. The age-old solitude and silence of the sea was broken by radio, forerunner of electronics.



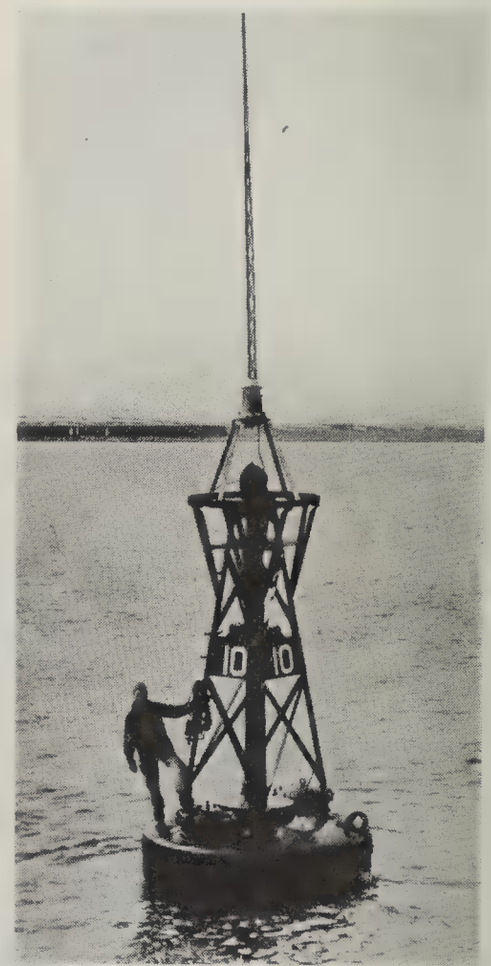
Midget Western Electric radio-telephone set intalled on a merchant-marine training ship. Units like this are also widely used on pleasure craft

The earliest ship transmitters were little more than a battery, a spark coil, gap, key, and antenna. The receiving equipment recorded incoming messages on a tape by means of a Morse inker. By 1902 the unreliable inker gave way to magnetic receivers with tuned circuits and headphones for reception. In 1907 crystal rectifier receivers were brought into use. The big spark-gap transmitters then were operating with a roar that could be heard for a mile and had a spark that looked like a thunderbolt.

The Poulsen arc transmitter was introduced to the United States in 1911 and carried on until vacuum-tube transmitters were perfected shortly before World War I. From then on, tube transmitters have gradually edged out earlier types of equipment, and now the changeover is complete, except possibly for a few small ships still carrying spark equipment. Today, tube equipment has an almost unlimited range on short waves.

Modern tube transmitters command instant silence when they send out the international distress call SOS (... — — — ..., adopted because of easy sending and recognition, not because the letters stand for "Save Our Ship"). Similarly, CQD, the first recognized distress signal, was formed by the addition of D for "Distress" to the general call CQ and did not mean "Come Quick Danger."

In the early days of radio navigation, a ship got a position "fix" by turning on its transmitter, calling



Coast Guard type TB-113 buoy radio-beacon installed near a harbor entrance. Twin transmitters and their storage batteries are stowed below the waterline in a sealed pocket within the buoy. The 15-foot vertical antenna is connected to the transmitters below

land stations having direction-finding equipment, then holding down the sending key while these stations manipulated loop receiving antennas and determined the compass bearings of the ship with respect to their own positions. They sent this information to the ship by radio. The navigator then drew lines on his chart corresponding to the bearings received from two or more widely-separated land stations and read off his position where these lines intersected. All this took a lot of time.

Later, many ships were equipped with their own radio direction-finders and the process was reversed. The ships merely tuned in identi-



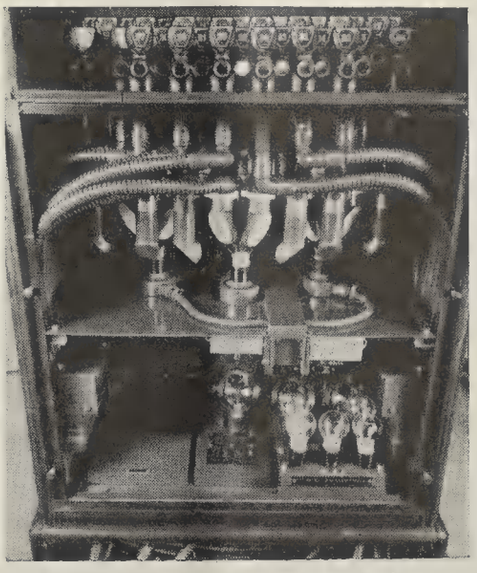
The number on the outlet from which smoke emerges in the Rich-Audio fire detection equipment for ships shows the location of the fire. At the same time, the smoke interrupts a light beam to a photocell and an alarm is sounded. Thus smoke can be detected visually, by smell, and by electronics

fiable radio-beacon shore stations, determined the bearings of such stations, and plotted their positions from these data. Certain selected shore stations and lightships transmitted continuously for this purpose during fog or thick weather, constituting radio "lighthouses" or radio-beacons.

RADIO BUOYS—Ships attempting to locate the entrances to narrow channels when visibility is poor could theoretically use their radio direction-finders in this same manner. Location of position by the intersecting line method is, however, often too slow where distances to be sailed are short and land is near at hand, or when in restricted channels. The inshore piloting problem has been very much simplified in recent years by the use of unattended radio transmitters housed in buoys anchored near channel and harbor approaches. These latest Coast Guard radio-beacons guide ships through difficult waters when abnormal conditions reduce the effectiveness of lights, bells, and horns. Pilots identify these radio buoys by their characteristic dot-and-dash code. Ships equipped with direction-finders can tune in such radio-beacon buoys and use the signals emanating from them to "home" on, riding down the radio waves to their source. The course is set to pass safely clear of the buoys and avoid collision with them.

The radio-beacon signalling equipment for a buoy consists of a 14-volt storage battery supplying all necessary operating power and capable of running the apparatus for three to four months without removal for recharging. A pair of radio transmitters feed alternately into a 15-foot monel-metal antenna, and a motor-driven flasher mechanism keys each transmitter automatically and alternately at intervals and controls the buoy light characteristic as well.

The twin transmitters are a safety precaution, required because reliability is essential in navigation aids. Failure of either transmitter would not put the buoy off the air, and such failure would be apparent only if it was noted that there were longer-than-normal periods of silence between transmissions from the automatic radio beacon.



Smoke-detecting cabinet with front panel removed to show the pipes going to various parts of the ship. Large lamp in the center provides the light that actuates the photoelectric cell

Great Lakes shippers, equipped with the world's most extensive non-military radiotelephone system, are now planning to use radar for further protection against the peculiar perils that beset their vessels.

The radar system is expected to minimize the danger of collision in blinding fogs of early spring even as the radio-telephone has helped reduce the hazards of wind and current. The ship-shore telephone system has been developed to the point where it keeps 580 vessels in constant touch with each other, home offices, Coast Guard stations—any point with a telephone.

Because the sets are operated by navigation officers generally unskilled in radio, fully automatic equipment has been developed for ship use. Lifting the handset turns on the transmitter.

The channel appropriate to distance and conditions is selected by dialing two digits, and the land call is placed with the shore station operator. Calls cost 75 cents, station to station, or 90 cents person to person, plus long-distance toll charges on land.

Ship-to-ship calls are free because there is no way of metering them. Shipmasters call each other frequently with queries on wind and current conditions and other matters of schedule and navigation. Weather reports are broadcast at frequent intervals throughout the day to all ships.

In another Great Lakes marine application of electronics, an automatic radio compass in the wheelhouse of a Pere Marquette Railroad car ferry keeps pilots "on the beam" during shuttle trips across Lake Michigan. Ship-to-shore radio-telephones are to be added to help direct the vessel's movements in all kinds of weather.

AUTO-ALARMS—The inability of ships such as the historic *Titanic* to contact the nearest rescue ship because its lone radio operator had just gone off duty underscored the need for continuous radio watch on all ships for safety purposes, and now auto-alarms are installed on all single-operator ships. These are receiving devices which will respond automatically to the international alarm signal sent by a ship in distress, sounding an alarm to notify radio operators and deck officers that a distress call is on the air. The international alarm signal consists of 12 four-second dashes spaced one second between dashes, sent on the international distress frequency of 500 kilocycles. The auto-alarm is chiefly intended for operation on ships carrying only one radio operator, but it may be installed on any vessel to guard the distress frequency during such times as the operator on watch may not be listening on that frequency.

The auto-alarm is placed in service by the radio operator during such times as he is not on watch and the vessel is under way. Upon receipt of an alarm signal, the auto-alarm will cause bells to ring. The ringing of the bells also serves to indicate when the auto-alarm receiving equipment becomes inoperative due to a failure of power or to the burning out of a tube. Only two models of auto-alarms are found on ships of the American Merchant Marine; one is produced by Mackay Radio and Telegraph Company, has a mechanical selector for picking out the correct signals for response, and is installed on Mackay ship stations. The other, having an electronic selector, is used on ship stations of the Radiomarine Corporation of America.

FIRE AT SEA—The addition of photoelectric smoke-detecting apparatus to the older Rich system for detecting smoke by sight and smell pro-

vides for ships at sea an automatic fire-alarm system comparable in speed and effectiveness with the finest modern installations in buildings.

Air samples from each protected space are drawn through individual pipe lines to the detecting cabinet, usually in the wheelhouse, by an exhaust fan. The pipe outlets are positioned in concentrated beams of light that illuminate smoke particles and provide visual detection. The air samples are discharged into the wheelhouse, so that smoke will also be detected by smell when present.

Each pipe line is provided with an automatically controlled solenoid valve that momentarily diverts the air sample to a long tube for photoelectric observation. A light beam is directed through this tube to a photovoltaic cell connected to a meter-type relay.

A motor-driven selector switch energizes one valve after another at four-second intervals, and drives a number-wheel indicating which line is being diverted at any instant. If no smoke is present, the number changes and another line is diverted for photoelectric inspection. Smoke causes operation of the alarm signals and stops the selector switch so that the number remains on the control panel to indicate the source of the smoke. This Rich-Audio fire-detecting system is made for ship use by Walter Kidde and Company, Inc.

The United States Navy has long recognized the value of electronics in the conduct of warfare, with the result that the vacuum tube is now one of the most important weapons of our Navy.

The year 1923 was marked by the opening of the Naval Research Laboratory at Anacostia, D. C. New developments achieved here include the first high-frequency and the first ultra high-frequency radio sets used by the fleet, the first multiple-reception radio system permitting the operation of a large number of receivers from one small antenna, the technique of producing quartz crystals for the frequency control of radio transmitters, the first crystal-controlled high-frequency, high-power transmitters (1924), special radio transmitting and receiving equipment for the dirigible U. S. S. *Shenandoah,* the sonic depth finder for measuring ocean depths from a ship under way, use of the hull and other parts of a ship's structure for the radiation of radio energy without a conventional antenna, an underwater sonic device to detect enemy submarines at considerable distances, and a system for the radio control of aircraft in flight that resulted in use of a considerable number of obsolete Naval aircraft as targets for anti-aircraft gun practice. A host of other research projects can be added to this imposing list, including many of the latest refinements of radar and sonar.

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MARINE RADAR

Will Give Navigators "All-Weather" Eyes

WHAT is probably the first practical civilian use of radar is found in the General Electric "electronic navigator" that can detect through darkness, fog, and storm the position of any above-water obstacles, such as lighthouses, buoys, icebergs, derelicts, other ships, and land, at distances up to 30 miles, depending upon the size and shape of the object.

This device operates on the radar principle of radio waves which are reflected from objects and are measured to give true bearing and distance of the object from the point of sending. It will revolutionize "thick weather" navigation by providing the mariner with an instrument to plot a safe course, even though his normal visibility is

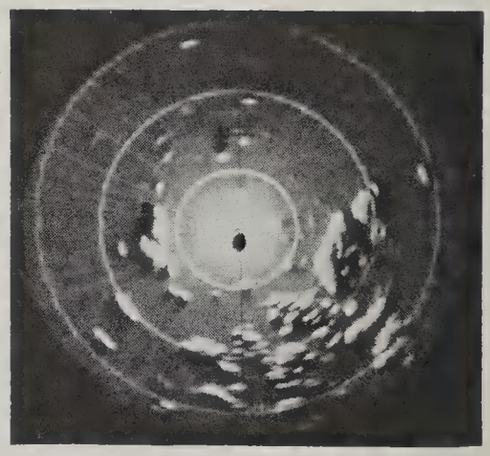


strongly limited by natural conditions.

The distances of objects from the ship are shown on the viewing screen of the electronic navigator in true proportions, being measured by a series of concentric "marker rings" electronically super-imposed on the picture screen. According to General Electric engineers, the measurement of distance so given is accurate to 1 percent.

Basis of the electronic navigator is a rotating antenna, located on the top deck of the ship and analogous to a searchlight, in that it sends out beams to locate obstacles in the ship's path. The difference, however, is that beams from the radar antenna, which are actually powerful radio micro-waves, are capable of penetrating fog or any other atmospheric conditions without hindrance. Moreover, they are sent out as "pulses" or surges of extremely short duration and at a very rapid rate.

As the radar waves locate an obstacle in the surrounding waters, they bounce off and are scattered, no matter what material the object is. Some of these echoes—or scattered waves—will return to the rotating antenna, which also acts as the receiving antenna during the time intervals between the outgoing pulses. After being amplified, these echoes are made to appear as bright spots on the face of a cathode-ray tube, which is somewhat similar to a television screen tube. The image thus formed gives the operator a



Left: Watching the screen of the electronic navigator, first peace-time version of war-time radar. Above: A photograph of the cathode-ray screen, showing how obstacles in the path of the ship are indicated. The operator can interpret quickly the kind of objects represented by the radar spots and their distance from the ship

"radar picture" of the obstacle, and the marker rings tell him how far away it is.

By controlling internal circuits, the operator may change the scale of the field to cover either a 2, 6, or 30-mile radius. Thus, when a ship is sailing in the open sea, the operator will use the 30-mile range until an object approaches to within 6 miles. Then, by turning a knob on his radar set, he is immediately presented with a larger scale chart, the outer radius of which is 6 miles. For very close work another turn of the knob provides a 2-mile radius chart on which objects may be observed down to about 200 yards.

Oil For Ships' Turbines

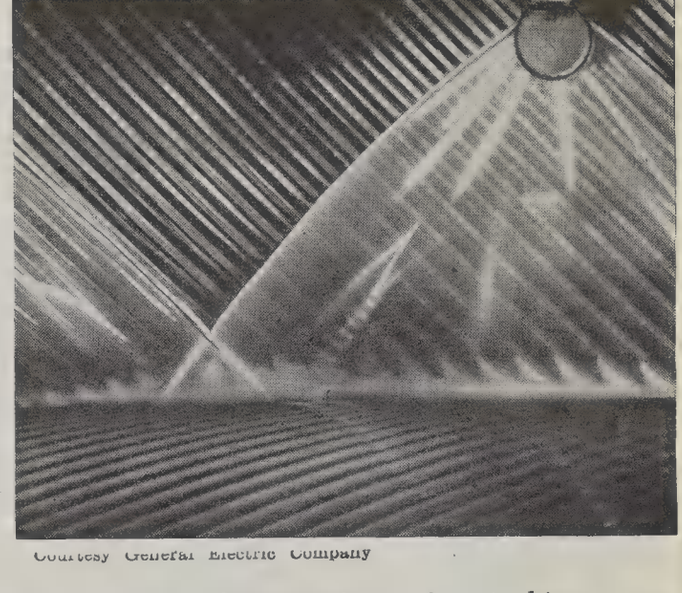
When Turbines Go to Sea, Lubrication Requirements are Complicated as Compared With Turbines on Land. Water Becomes a Major Problem by Intensifying Such Undesirable Features as Rust and Emulsification of the Lubricant. Can Petroleum Technology Keep Pace With Demands?

FAR different are the marine turbines of today from those which propelled the ships of only a generation ago. Early marine turbines were operated at low steam temperatures and pressures. Since they were usually large and slow, lubrication was relatively simple. Specially refined oils were not required and, furthermore, none was available. With the introduction of the newer alloy steels in the construction of marine steam turbines, a rapid increase in steam pressures and temperatures was made possible. Present-day turbines operate at pressures of from 400 to 450 pounds per square inch and, in some instances, 1250 pounds. Several ships are now building that will carry steam pressures of 1500 pounds gage. The old cast-iron machines of yesteryear were limited to 350 pounds pressure. Temperatures today range from 700 to 850 degrees, Fahrenheit, as compared to 450 degrees a generation ago.

The increase of steam pressure and temperature has depended on and has followed closely the development of materials suitable for high temperature application. While higher pressures and temperatures mean greater turbine efficiency, they brought problems in design which necessitated more elaborate and at the same time more efficient lubricating systems.

In early turbines the oil was used merely for lubrication, and its cooling function was of secondary importance. Old type lubricants lacked stability toward oxidation and rapidly became inefficient through deterioration. As turbines progressed, even the better refined oils proved unsuitable under the severe and exacting operating conditions. Deterioration of the oil resulted in emulsification with water and deposition of sludge. Such oils thus became unsafe for marine use. As turbine designs called for higher temperatures and pressures, thus attaining greater turbine efficiency, the demands on the lubricating oil became more exacting; they were required to not only lubricate but to act as highly efficient coolants as well. The chemists of the petroleum industry, through the medium of modern refining processes and the use of additives, improved turbine lubricating oils to keep pace with mechanical progress. In fact, some authorities now predict that the best grade of modern marine tur-

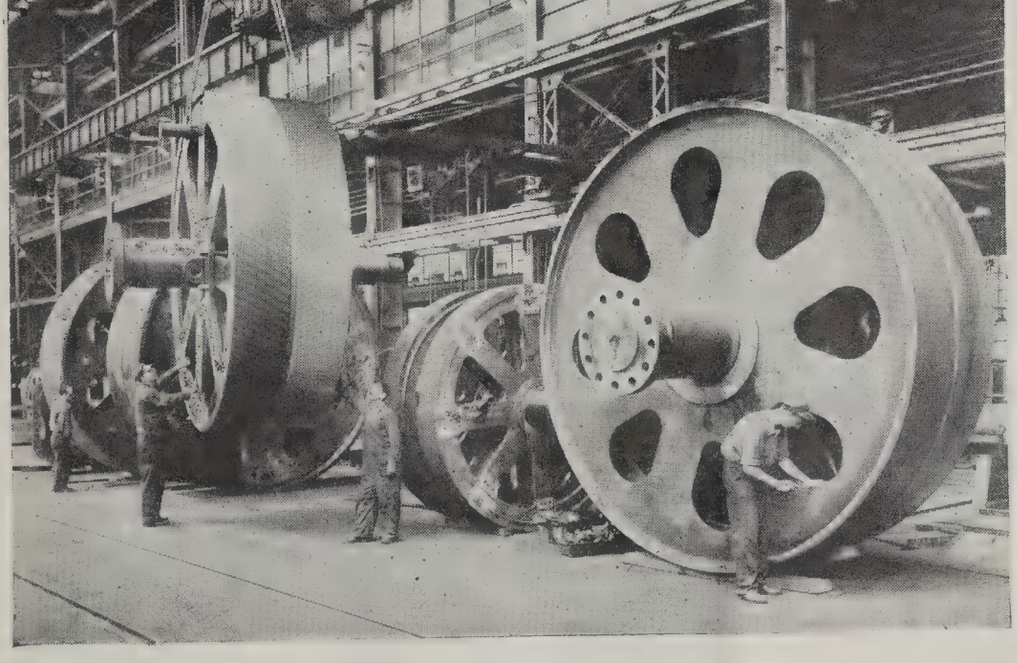
Right: Oil is sprayed evenly onto meshing teeth of rapidly moving turbine gears



Courtesy General Electric Company

Below: These gigantic turbine reduction gears require same care in lubrication as a chronometer

Courtesy Westinghouse Electric Corporation



bine oils, if properly cared for in service, will last for the life of the turbine. Contrary to the belief of many, lubricating oils do not wear out; they are rendered unsuitable for continued use by contamination.

SPECIFIC PROBLEMS—Lubrication of marine steam turbines presents problems similar to those encountered in lubricating land turbines, except that condensation of moisture and infiltration of salt water into the oil system is greater in marine installations. Also, the reduction gears of marine propulsion units are lubricated by the same oil used in the turbine bearings. Because of this, it is necessary to compromise in oil viscosity. Hence a somewhat higher viscosity oil is used for marine turbines than for stationary land units. An oil viscosity of from 300 to 500 seconds Saybolt Universal at 100 degrees, Fahrenheit, is generally used at sea today.

Marine turbines are essentially high-speed units, operating at from 3600 to 12,500 revolutions per minute. The rubbing speeds of turbine spindles are among the highest found in heavy mechanical equipment. Through finely finished reduction gears, these high-speed prime movers turn propellers that rotate at only 90 to 100 revolutions per minute, although propeller speeds of 400 revolutions per minute are not uncommon.

Some of the most accurate manufacturing processes in heavy industry are required to build marine turbines and gears. The precision requirements are such that the big marine gears are cut in air-conditioned rooms so that temperature changes cannot distort the metal and affect the finish accuracy. So delicately balanced are these gears that a pressure of one four-thousandths of their weight is sufficient to turn them. Gears measuring 12 feet in diameter and weighing 25 tons are not unusual in marine propulsion units. These gears are machined to limits within three tenths of a mil, or about one fourth the thickness of a cigarette paper.

Naturally, high speeds and close tolerances limit the viscosity of the lubricating oil that can be used. Oil of high viscosity will result in unnecessary internal friction and increases in temperature generated within the oil itself. This again demands that the lubricant show the least body change through the operating temperature range.

ATTRIBUTES OF OILS—There are four important service factors in marine turbine lubricating oils: the possibility of the oil being overheated; the possibility of water contamination; the occurence of oxidation; and the ultimate formation of organic acids and sludges.

Only an oil that can withstand all of these adverse conditions is effective in turbine lubrication. It should readily separate from water with which it may come in contact and it should be of such viscosity as to function satisfactorily in the particular size and type of turbine being lubricated.

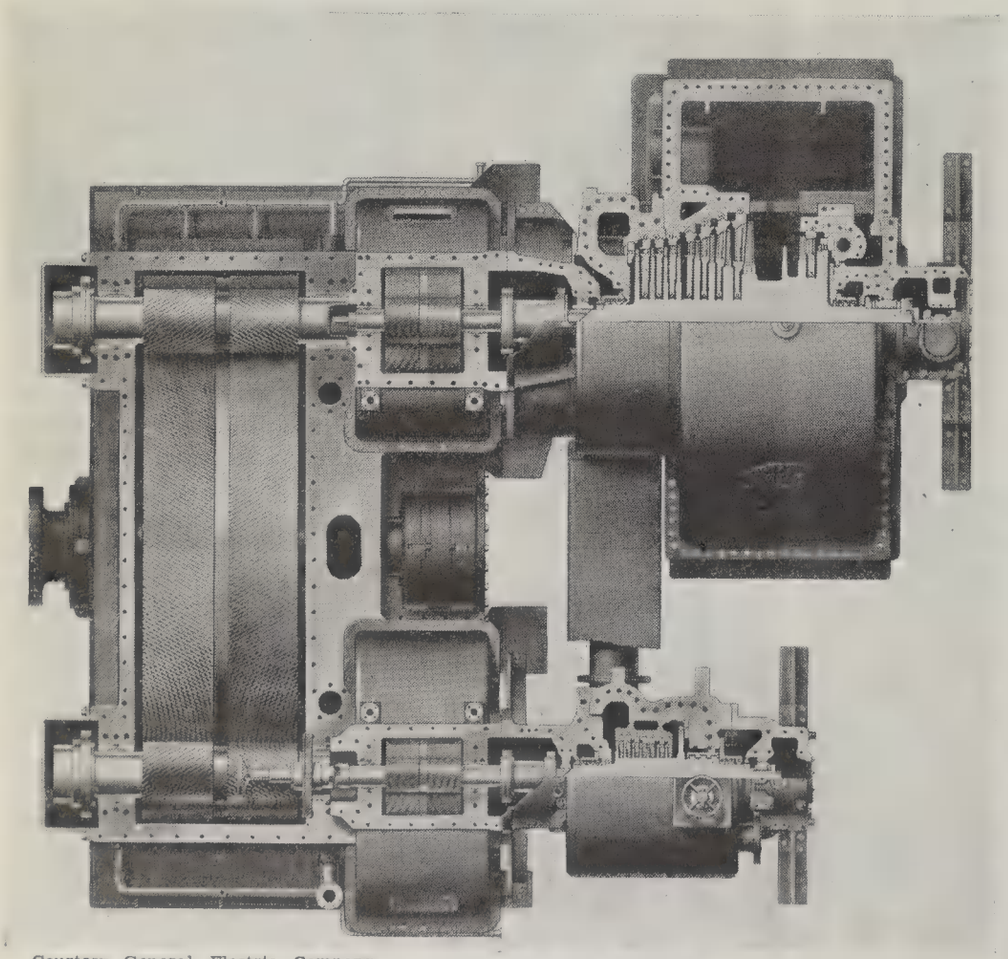
Marine turbine oils are so refined and processed that they are free from easily oxidizable compounds, dirt, or other impurities. They are filtered through special clays or other purifying materials after they have been subjected to a number of special refining stages. Anti-oxidants and anti-corrosion materials are added to improve stability. Incidentally, some of these additives are extremely expensive.

OXIDATION—Despite the selection of the best grades of crude petroleum, the highest degree of refining, and the use of protective additives, however, a certain amount of oxidation will occur in turbine lubricating oil. Petroleum, like all organic matter, will oxidize slowly in the presence of air. This rate of oxidation can be successfully retarded and controlled.

The rate of turbine oil oxidation generally increases with a rise in operating temperature. The importance of temperature control is therefore obvious. Oddly enough, low temperature operation can also produce disastrous results, such as foaming, formation of emulsions, and corrosion.

Severe churning, which occurs in gear cases, together with contamination by extraneous impurities such as metallic particles, or water and dirt, accelerates oxidation of oils. The rate of oxidation depends in great part upon the ability of the oil to resist the action induced by the impurities and upon the extent to which these impurities are present in the oil system. Products of oxidation may be formed which are inert and have little or no detrimental effect on the operation of the turbine. But some deterioration products may produce sludge and deposits due to oxidized hydrocarbons. Such deposits may interfere with the heat transfer in the oil coolers, foul the oil system, and, in severe cases, may result in interruption of the oil supply to the bearings and gears, causing damage to the unit.

Water in turbine oils induces formation of rust, both black and red. These metallic oxides, being catalytic, promote oil deterioration. The black oxides differ from the more



Courtesy General Electric Company

Looking down on a geared marine steam turbine, with covers removed. In lower part of the photo is shown a high pressure turbine, in upper part a low pressure turbine. Lubrication of this high-speed, precision built machinery is an intricate problem

common scaly, amorphous red rust in that they are crystalline, magnetic, and form most readily at elevated temperatures where excess air is present with limited moisture. Consequently, black oxide is more frequently recognized on such surfaces as governor pilot valves, operating cylinders, oil submerged areas, and occasionally on the main journals. It is quite hard and abrasive and adheres to the surfaces on which it forms. Infrequently it will be found that scales of red rust have been subjected to conditions that result in conversion to the much harder crystalline black oxide, which then presents the multiple hazard of abrasion of bearings, stoppage of small orifices, and interference with movement between parts having close clearances.

EMULSIFICATION — Water, in other ways as well, is the greatest source of trouble to marine turbine operation. Water itself does not harm the lubricant. Its reactions with metals and oil deterioration products, however, are most harmful. Steam from leaking gland seals and condensation of humid air in oil tanks and gear cases are the most frequent sources of water contamination.

When water is churned with an oxidation stable oil, a mixture is formed which quickly separates into its component parts—water and oil. Although limited oxidation is not in itself detrimental to the lubricating value of an oil, excessive oxidation will reduce the oil's ability to separate from any water that may be present. The presence of dirt and metallic particles in the oil accelerate its deterioration through oxidation. This results in permanent emulsification and causes the eventual formation of harmful deposits and sludge.

Emulsions also impair the lubricating qualities of the oil. In extreme cases actual rupture of the oil film will result, followed by inevitable scoring of bearings and gear teeth. Emulsified oil sludges deposited in the supply passages to bearings and gears may restrict oil flow, thus reducing the rate at which induced and frictional heat is removed. Increased oil and bearing temperatures result in oil thinning and decreased film strength.

FOAMING—A characteristic of all oils when subjected to extreme agitation and churning is foaming. Since this action has the effect of increasing the volume of the oil, it is apt to overflow the reservoir and return oil lines, resulting in loss of valuable oil as well as creating a fire hazard. If foaming oil is delivered to the bearings, it may break down under pressure, with resulting bearing failures. In addition, foaming oil, presenting a much larger oil surface to air at elevated temperatures, increases the rate of oxidation.

TOMORROW?—The successful operation of over a thousand ships of our merchant marine, propelled by steam turbines, is apt to overshadow the part American petroleum companies are taking in the manufacture of lubricants essential in keeping these ships running under all conditions of weather and climate.

What faster speeds, higher temperatures, and greater pressures marine turbines of the future will have no one can foretell, but as in the past and today, petroleum research will undoubtedly provide adequate lubricating oils for their safe and successful operation.

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OIL RESOURCES

Increased by Research As Well as Drilling

ADVANCES over the past 25 or 30 years in the techniques of recovering oil from its natural underground reservoirs have been great, Mr. E. Holman of Standard Oil declared in a recent article in *The Journal of Commerce*. The industry actually has "found" as much oil, by bringing about higher recovery through research and engineering studies, as has been located by the drill. This has been a real achievement.

It is interesting to reflect that, around the time of World War I, recovery of 20 percent of oil in place was generally accepted as normal. Today, in contrast, recovery of some 80 percent of original oil in place is regarded as possible in modern, efficiently operated fields—a fourfold increase. Whereas in early days gas and water were considered only nuisances, today careful observation of reservoir pressure trends is standard practice and the control of gas-oil ratio and the movement of edge and bottom water is recognized to be of paramount importance for high ultimate yield.

An important factor in the progress of this science has been the open discussion of new theories and findings before the several industry associations and technical societies through which the results of various laboratory and engineering studies were exchanged and compared. The ensuing discussions, and even the controversies which arose, have served both to educate others and to spur work along new lines of thought.

HELIUM GAS

Traces Movement of Underground Oil and Gas

A NEW and valuable application for helium is currently being investigated by the United States Navy in co-operation with the United States Bureau of Mines, says *Oil Weekly*. The new application for helium is as a ferret to trace the underground movement of reservoir fluids in gas and oil fields, thereby enabling gas and oil producers to operate their properties more efficiently and to increase their recovery of these natural resources.

This use of helium involves injecting it into the underground gas and oil reservoir at one or more carefully selected locations, through well bores, and detecting its presence in the gas and oil produced from adjacent wells. The length of time required for the helium to travel from the injection well to each of the producing wells, and also the quantities of the injected helium found in each producing well, will enable petroleum engineers and geologists to determine reservoir conditions between wells and the pattern of drainage of the gas and oil through the porous reservoir rock. Because helium is chemically inert it is uniquely valuable for this purpose in that its identity, which can be readily determined by laboratory analysis, is not lost by combination with reservoir rocks or fluids.

RAW MATERIALS

Found by Dozens In Petroleum

PETROLEUM yields dozens of raw materials from which chemistry may build an infinite number of useful organic chemicals, Cary R. Wagner, consulting chemist, declared at a recent meeting of the American Chemical Society.

More than 200,000 different compounds have been produced from the dozen or more hydrocarbons found in by-product coal tar, he explained. But he listed 38 hydrocarbons, "only six of which are identical with those found in coal tar, which may be used as raw materials in manufacturing organic chemicals from petroleum."

To find further raw materials Standard Oil Company (New Jersey) is planning to build two research laboratories costing $8,000,000.

To Europe By Air

With the Post-War Era Now Upon Us, Americans Will Want to Go to See What is Left of Europe. To Many the Ocean Steamer is Too Slow But the Plans of the Big Transatlantic Airplane Companies Will Enable Anyone to Take a Vacation in Europe at a Surprisingly Small Cost

THOUGHTS of many Americans are now turning to a possible visit to Europe. So it is quite timely to speculate on what the airplane has to offer people who wish to fly across the Atlantic Ocean. Will there be sufficient safety and comfort, and will the fare be reasonable enough to make such a flying visit to Europe possible for most people?

SAFETY—Perhaps the first question in everyone's mind is—safety. To anyone who has gazed at the wide expanse of the ocean from the deck of a steamer, especially during a storm, its vastness and power are apparent. The would-be air traveler can well imagine the hazards of an emergency landing in rough weather.

But for years exhaustive research has been made of climatic and meteorological conditions over the Atlantic Ocean, in Iceland, Greenland, Labrador, Newfoundland, and the Azores. Flight engineering surveys were made back in 1937, and since the inauguration of transatlantic service in 1939 much additional data have been obtained to ensure the safety of such flights.

Among the first of such safety developments was the inauguration of the "multiple flight crew" by Pan-American World Airways. In the Caribbean Sea operations of aircraft, a four engined flying boat was manned by a standard crew of only four. For the more hazardous transatlantic flights, larger and more specialized crews were found to be necessary. The primary personnel requisites of Atlantic flights are expert direction of flight, piloting, navigation, control and care of power plants (engines), maintenance of communications, and passenger service. All are under the command of a captain who is also an experienced pilot. His duties and responsibilities are in a way equal to those of the captain of any huge surface liner. He holds the rank of Master of Ocean Flying Boats, is a qualified aeronautical engineer, a meteorologist, a radio operator, and a mechanic. And above all, he is a man of courage, cool judgment, and decision. Directly responsible to the Captain are five officers, specialists in the primary departments of piloting, navigation, engineering,

TRANSATLANTIC AIR SERVICE

1945 Summer Schedule

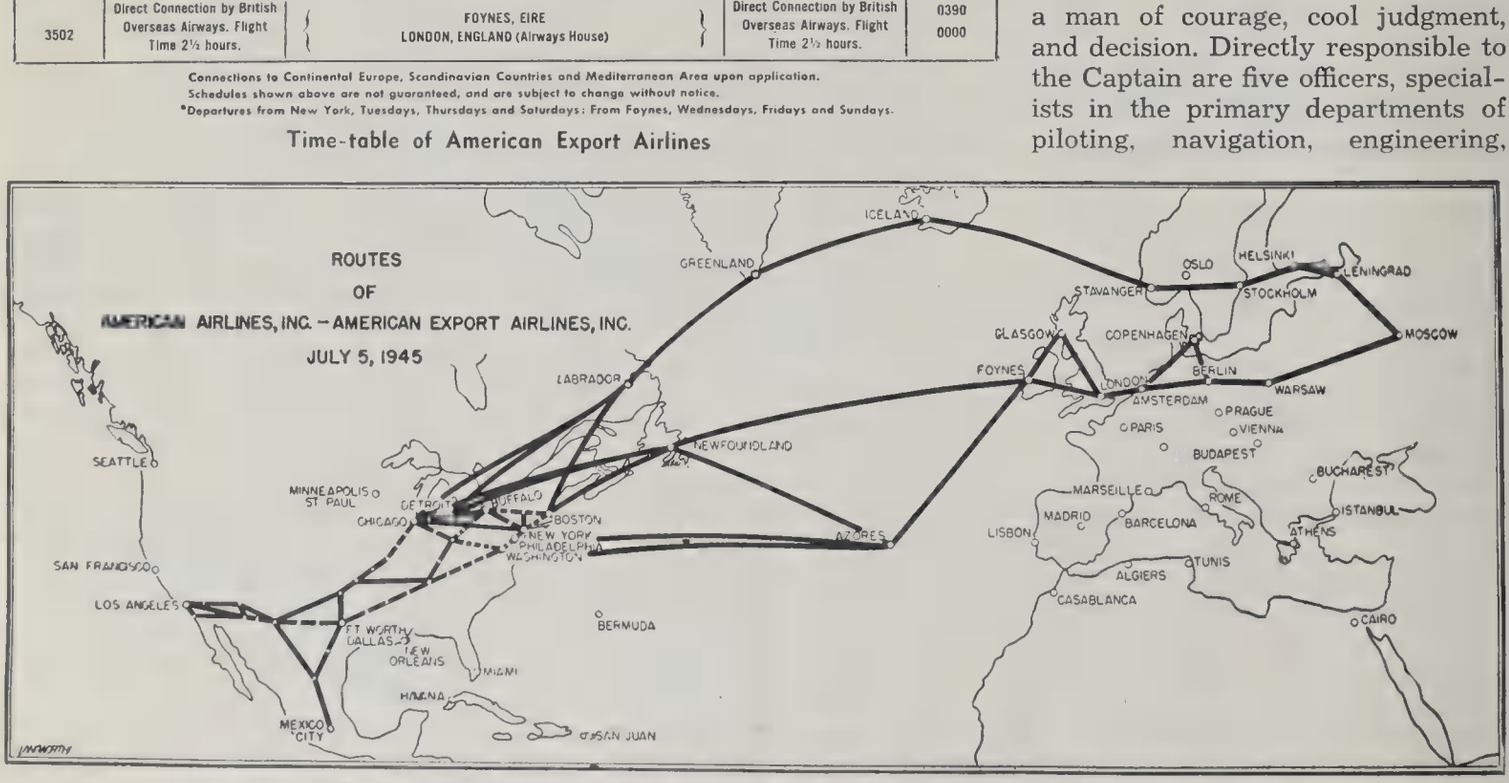
U. S. A.—Newfoundland—Eire—England and connections beyond
Service operated with The Famous Four-Engine "Flying Aces"

MILES	GREENWICH TIME	LOCAL TIME	*3 ROUND TRIPS WEEKLY	LOCAL TIME	GREENWICH TIME	MILES
0000	1200	8:00 A. M.	Dep. . . . NEW YORK, N. Y., LaGuardia Field (Marine Terminal) . . . . Arr.	2:45 P. M.	1845	3502
1111	1915	4:45 P. M.	Arr. . . . BOTWOOD, NEWFOUNDLAND . . . . Dep.	9:00 A. M.	1130	2391
	2100	6:30 P. M.	Dep. . . . BOTWOOD, NEWFOUNDLAND . . . . Arr.	7:15 A. M.	0945	
3112	0830	9:30 A. M.	Arr. . . . FOYNES, EIRE (Shannon Airport) . . . . Dep.	8:00 P. M.	1900	0390
3502	Direct Connection by British Overseas Airways. Flight Time 2½ hours.		FOYNES, EIRE LONDON, ENGLAND (Airways House)	Direct Connection by British Overseas Airways. Flight Time 2½ hours.		0390 0000

READ DOWN ↓ READ UP ↑

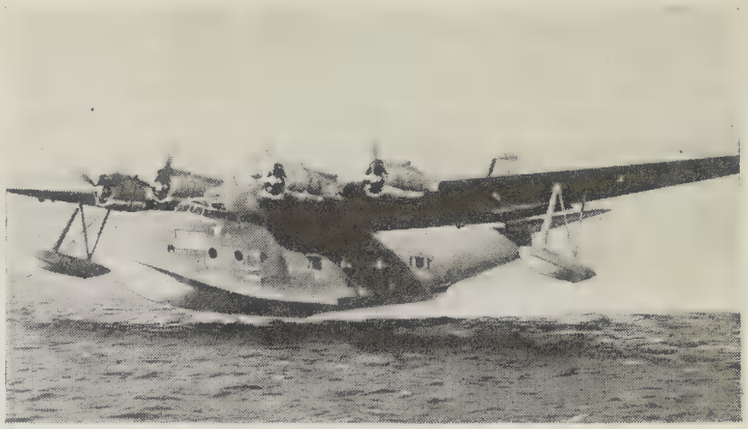
Connections to Continental Europe, Scandinavian Countries and Mediterranean Area upon application.
Schedules shown above are not guaranteed, and are subject to change without notice.
*Departures from New York, Tuesdays, Thursdays and Saturdays: From Foynes, Wednesdays, Fridays and Sundays.

Time-table of American Export Airlines



Two combined airlines produce a one-system over-land and over-seas service







Above: A B-314 of Pan-American World Airways, now being used in transatlantic service.
Upper right: A Vought-Sikorsky Flying Ace of American Export Airlines.
Right: The projected Consolidated-Vultee six-engined plane designed to carry 204 passengers at 310 miles an hour

communications, and passenger service. Each of these five has a fully qualified assistant to relieve him during rest periods.

The crew have available to them every known navigational aid. Drift of the plane, caused by side winds, is checked by the use of thin glass flasks containing pulverized aluminum which, when dropped from an airplane, break on striking the ocean surface and produce a bright silvery slick visible for miles. This aids the navigator to check the plane's "ground speed" as well as the drift. Celestial "fixes" are made at least once every hour, dead reckoning position is computed every half hour, while radio bearings from direction-finder stations ashore or bearings on ships at sea provide an additional check.

Transocean aircraft like the B-314 have four engines, but can fly indefinitely on only two. All engines of the big ocean flying ships are accessible by means of companionways built through the interior of the wings. This permits periodic inspection of the engines during flight, and, if necessary, repairs and servicing. Hundreds of such repairs and servicing operations have been made during flights across oceans.

"Scientific Control of Flight" is a process by which the most efficient performance of the aircraft is charted on a course under the most favorable flying conditions. Before each Atlantic flight the crew assigned to the plane, together with ground maintenance and service engineers, put the plane through a series of flying tests in which the air speed, fuel flow, engine revolution and oil flow indicators, and other instruments including the compass are carefully checked. Weather reports from all sources are obtained and a final weather map is prepared for the flight. Careful computations of efficient speed and altitude, and of fuel consumption, yield the best three dimensional flight path. The flight-time analysis is checked during the actual flight by what is known among flying men as a "Howgozit Curve." This scientific flight control is kept up to date by continued research.

GROUND SERVICES—The ground services which ensure the continued safe operation of the great transatlantic aircraft are elaborate, their details carefully worked out, and the maintenance and overhaul service so thorough that a separate article would be required adequately to do it justice. This ground service, plus efficient flying technique, has made possible not hundreds but many thousands of Atlantic flights. Millions of miles have been flown already, carrying thousands of passengers on schedule, as well as mail and air freight. There have been one or two minor accidents, but when one considers the flight miles in comparison with railroad and steamship mileage, the comparison is favorable to the airplane.

The recent announcement of the availability of a flame-proof gasoline for use in all passenger carrying aircraft transports will increase the safety factor of ocean flying to an unprecedented degree. This new gasoline is as safe to handle as ordinary kerosine, and if a plane should crash into the ocean, the danger of tons of gasoline spilling and igniting is negligible. Also, if fueling in the air is adopted on transocean flights, it can be accomplished with safety and minimum risk of fire.

COST—A ride on the modern "Magic Carpet" is surprisingly cheap, as shown by the list of fares submitted to the Civil Aeronautics Board by the transatlantic flying companies. To London via Newfoundland and Ireland is $148, to Leningrad $167, to far-off Calcutta only $332. When one considers the time saved and the never-ending number of "tips" dispensed with, these fares are remarkably low. For luxury travel the airplane is much cheaper than first class steamer.

At present the flying time from New York to London is roughly twenty-four hours, depending on weather conditions. This time will be considerably reduced when and if jet-propelled planes are perfected for ocean travel. In fact, it may be possible to fly westward at the same speed as the earth revolves, in which case a plane would leave London at, say, noon, and arrive in New York at noon the same day! But that is still in the future, although perhaps not so far off.

TYPES OF PLANES—While at present the two American companies engaged in transatlantic flights use flying boats, the Pan-American

World Airways using the Boeing 314, and the American Export Airlines the Vought Sikorsky Flying Aces, the newer types will in all likelihood be land-planes. This may sound surprising, but there is excellent justification for the selection of the land-plane. As has been pointed out before, when four engines are used, it is possible to fly on only two. And with the new types designed to use six engines, there is little likelihood of engine failure sufficient to compel the plane to alight on the ocean. And if a land-plane should have to alight on the water, it could remain afloat in a rough sea fully as long as a flying boat. However, a great safety factor is that transocean planes will fly over well frequented ship lanes and in the event of an accident which should necessitate the passengers having to take to the carbon-dioxide inflated life rafts, it would not be long before they would be picked up by one of the many passing steamships. There would be little need for the use of the safety kits with which the rubber life rafts are provided. These include fishing tackle, portable radio signalling devices, sunburn protection equipment, and so on.

The flying boat has, of course, the advantage that it can use coastal waters for take-off, so that when heavily loaded it is not impeded by the shortness of a runway. In other respects the advantage lies with the land-plane which is faster, more economical to operate, costs less, and is cheaper to maintain.

Much mystery surrounds the details of some of the new planes being projected for transatlantic flight. The Amex Model VII, as it is called, will fly 4000 miles non-stop at a cruising speed in excess of 296 miles per hour. It will carry 108 to 125 passengers, depending on the interior arrangements. The largest is apparently the six-motored Consolidated-Vultee Aircraft Company's plane, which is said to be able to carry 204 passengers at a cruising speed of 310 miles per hour. Cabins will be supercharged, enabling the plane to fly at an altitude of 30,000 feet, well beyond the reach of storms. Payload will be 50,000 pounds at 4200 miles cruising range. Flying time to London will be a little more than nine hours. This plane will be double decked, with lounges, rest rooms, and other facilities for the passengers' comfort.

Enough has been said to show how full of confidence and energy are the operators of overseas airlines. In the not far distant future there will be unbelievable schedules, complete safety, an enormous increase in the number of travelers by air to Europe. As far as business travel is concerned, flying will be first choice. And to those on pleasure bent, but with only a limited time at their disposal, the airplanes will be the answer. Now a business man or woman who can only spare two or three weeks from work will be able to take a vacation trip to Europe, see most of the leading capitals, traveling in Europe by air also, and be back in the United States without overstaying the time limit. This was impossible before the war. Thousands will, thanks to the airplane, be able to visit Europe for the first time in their lives, and do so at a remarkably low cost. But there will be many who will still wish to savor the luxury and freedom from care of a ten-day boat trip across the Atlantic in the heat of the summer as perhaps the very best part of the whole European trip.

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SUPERCHARGER

Built in Small Size
Yet Highly Efficient

A REMARKABLE turbo-compressor, engineered by Wright Aeronautical Corporation and no bigger than a hat box, is shown in a cut-away model being operated by W. E. McClure. It is said to be lighter, more compact, and better adapted to varying aircraft conditions than any previous model. Within its clam-shaped housing, the exhaust of a



Model of "hat-box" supercharger

Wright Cyclone 9 of 1200 horsepower will turn the turbine of the supercharger at 25,000 revolutions per minute and develop the equivalent of 150 horsepower. The turbine, in turn, will drive the compressor to provide ground level engine-operating conditions at high altitudes.

The beneficial effect of the turbo compressor on performance is well known; it is perhaps not so generally recognized that it is also helpful to passenger comfort. The baffling of the exhaust in its surge through the turbo helps to reduce the noise level of the aircraft considerably, so that passenger fatigue is reduced. Also, the turbo compressor may be employed in cabin pressurization.

PRIVATE FLIGHT

Will be Reasonable
in Cost

THE NEW private planes will be safer, more efficient, more easily controlled than anything available before the war. They may be provided with only two controls (that is, elevator and ailerons alone without rudder) and tricycle landing gears which will permit cross-wind landings.

But the question still remains: How much will it cost to own and operate a private plane? John W. Friedlander, president of Aeronca Aircraft Corporation, a pioneer in the development of the private plane, discussed the question in a paper presented before the Society of Automotive Engineers.

If the airplane is little used during a year, its cost of operation will be prohibitively high. Thus, for a 65 horsepower, two-seater airplane selling at $1500, cost per annum will be $641 for 50 hours flying, but the cost will be only $1286.55 for 300 hours of flying per year. And 300 hours seems to be a reasonable amount of use.

The actual distribution of cost, on a basis of 300 hours a year, is as follows: Hangar, $180; insurance, $122.25; depreciation, $240; gas at 25 cents a gallon and 1350 gallons a year, $137.50; oil, $16.60; inspection and miscellaneous repair, $300; overhaul, $90.

All these figures and the total itself seem reasonable, but not cheap. And what will be the cost per mile? On a 300-hour basis, it will be about 4½ cents a mile, which also is reasonable but not cheap.

The greater costs of flying are compensated for by its greater speed as compared with the automobile. Mr. Friedlander has presented a most authoritative analysis of private plane costs. It will be interesting to see how the public will finally act when, with the favorable factors listed above, there are coupled these reasonable, though by no means cheap, figures of operational cost.

Water—A Marine Problem!

Design of Boilers for Ships of the Future May be Radically Affected by Present and Continuing Work of Chemists on Methods of Boiler Water Treatment. Proper Steaming Conditions Can Be Maintained Only if the Chemical Balance of the Boiler Water is Suited to the Installation

By A. C. PURDY

FRESH water supply presents one of the gravest problems encountered at sea. No way yet has been found to utilize directly the boundless water of the oceans for many of the important needs of marine transportation. As a consequence, the handling of fresh-water supplies is a prime marine problem. Water for steam boilers of ships must not only be conserved, but it must also be treated as necessary to minimize corrosion and to prevent scale and thus to give boilers the highest possible steaming efficiency. Obviously, the results of such treatment conserve space, always at a premium aboard ship, by saving both water and fuel.

Certain problems of modern high-pressure stationary plants may become acute in the marine field when pressures, temperatures, and ratings move upward in future ship design. No radical increases in pressures, temperatures, and ratings have occurred recently in American merchant ship construction. Pressures of 350 to 400 pounds per square inch were typical of 1933 construction, while 450 pounds per square inch is representative of present design, excluding experimental installations such as the *Examiner* and some naval vessels.

During the decade 1923-1933 the theory and practice of water conditioning by control of chemical balance in the boiler water to prevent scale was developed and expanded in stationary installations. It was introduced into marine units in 1930. During this same period there was a rapid upward trend in operating pressures and steam output and square feet of heating surface per boiler unit in stationary practice, which apparently is related to these advances in water conditioning.

By controlling the excess soluble phosphate in the boiler water, the scale-forming calcium and magnesium salts in the feedwater will be deposited as non-adherent sludge rather than as adherent boiler scale. During the past ten years this use of phosphate for scale prevention has become quite generally accepted in marine boiler operation.

Foaming and priming probably gave more trouble in the old Scotch boiler and reciprocating-engine installation than in present-day water-tube boilers. However, it is still necessary to limit concentrations of dissolved and suspended solids, particularly the former, and of boiler water alkalinity to assure proper steaming conditions in modern installations.

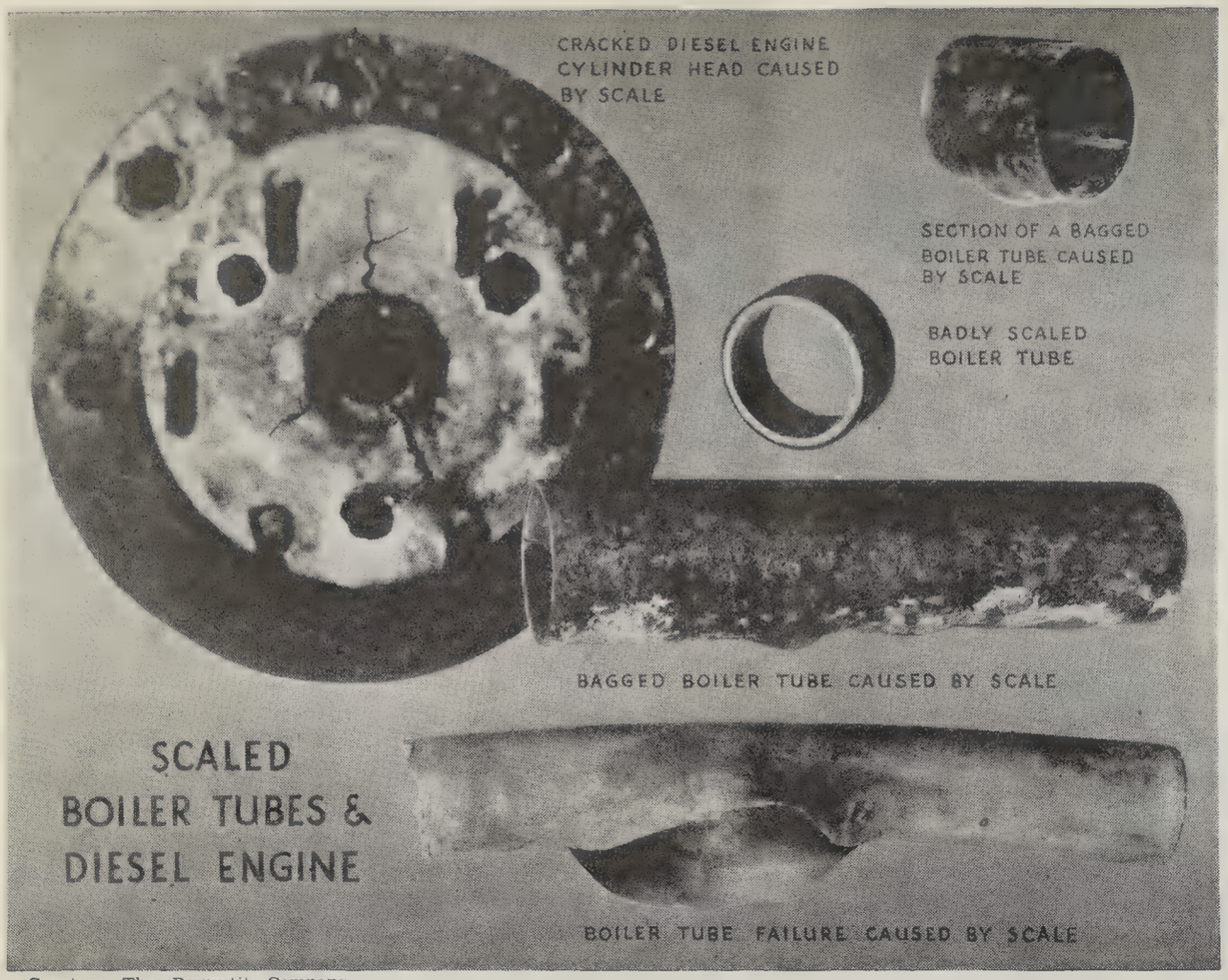
The importance of maintaining adequate protective alkalinity in the boiler water is generally recognized. The best alkalinity range varies with the installation, the aim being to establish and maintain a thin non-reactive iron oxide film



Courtesy Bethlehem Steel Company

S.S. *Examiner* of American Export Lines in which many experimental engine-room installations were tried, including a boiler with 1200 pounds pressure per square inch

Abstract of an address delivered before the Society of Naval Architects and Marine Engineers. The author is connected with the firm of Bull and Roberts, consulting chemists.



A few examples showing the effects of water in boiler tubes and other parts of marine installations. Scale is a constant source of trouble to marine engineers

Courtesy The Permutit Company

between steel and water which prevents any reaction between them. However, the caustic concentration must not be so excessive as to promote intergranular cracking of the metal or dissociation of the steam generated.

Of prime importance in preventing corrosion is the satisfactory deaeration of the feedwater. General acceptance of the deaerating heater in modern marine installations has been of great assistance. When properly operated, several available types have given excellent results.

METAL CRACKING—The basic factors causing boiler metal cracking are static or dynamic stresses acting in conjunction with corrosion. The corrosion may result from caustic or acid water conditions or from dissolved or bonded oxygen; and it can be retarded by water conditioning. Static stresses are inherent in the boiler as erected while dynamic stresses are set up by operating conditions.

Experience and study have established that caustic embrittlement of boiler metal can take place only when the following conditions exist simultaneously: A boiler water which, when concentrated, is embrittling; sufficient stress in the boiler metal; concentration of the boiler water to a high degree; contact of the concentrated boiler water with the stressed metal.

Two general methods for the chemical prevention of embrittlement have been suggested. Inhibitors such as sodium nitrate or tannin may be added to the boiler water. Tannin is effective only at relatively low pressures—below 400 pounds per square inch, but the efficiency of these inhibitors has been well established. Metal embrittlement also may be controlled by preventing high caustic concentration. This may be done by eliminating free caustic and controlling the protective alkalinity in the boiler water by means of various salts, such as tri-sodium phosphate.

The concentration of caustic may be controlled also by the presence of a highly soluble salt which will concentrate with the caustic soda and thus dilute it. Chlorides are salts of this type.

Fortunately, failures due to intercrystalline cracking of metal have apparently been very rare in marine boilers. It has been reported that the United States Navy has never had a case of this sort.

AS PRESSURES RISE—At pressures below 500 pounds per square inch, control of the phosphate balance prevents scale effectively and the efficient operation of deaerating heaters in conjunction with control of boiler water alkalinity prevents corrosion. Embrittlement has not been encountered in marine operation at these pressures and reasonably low alkalinities. But this does not mean that the problems of boiler water conditioning are a closed book. Stationary plant experience with higher operating pressures, supplemented by marine experience of some two and one-half years with the *Examiner* using pressures up to 1200 pounds per square inch, confirms the wisdom of resisting a temptation to standardize and to freeze the development of boiler water treating and testing methods. Progress must be made to meet the new problems of higher pressures, temperatures, and ratings.

As operating pressures rose above 600 pounds per square inch, a new group of siliceous deposits began to appear. The control of the phosphate equilibrium is not effective in preventing deposition of silica and sodium silicate, or sodium-aluminum and sodium-iron silicates. It became necessary to hold silica and alumina in the boiler water to a minimum and to limit, if possible, through boiler design and operation, the rate of heat input to the boiler surfaces. This approach has proved helpful but not always entirely satisfactory.

Corrosion of boiler surfaces by dissolved oxygen carried into the boiler by the feedwater has ceased to be a major problem on marine installations equipped with a properly functioning deaerating heater. However, the boiler water itself contains 88.9 percent of oxygen by weight bonded to hydrogen in the water molecule. Conditions under which this oxygen may be liberated

and combined with the boiler metal occur with greater frequency in the higher rating and temperature range of high-pressure boilers. Only a narrow band of optimum protection exists at 590 degrees, Fahrenheit, (1418 pounds per square inch) with attack on boiler steel increasing with a rise in either alkalinity or acidity. With proper boiler water control, acid attack may easily be prevented, but certain operating conditions may give high local concentrations of alkalinity and oxidation of the boiler steel by oxygen from the water molecule. This may occur in areas of steam blanketing or film boiling where the boiler water is highly concentrated, and continued attack causes grooving or channeling with ultimate failure of the tube.

As pressures rose above 1000 pounds per square inch and stationary boiler designs called for higher ratings and higher rates of heat absorption, the limitations of considering boiler water problems only from the standpoint of chemical balance become evident. A new approach is necessary, and it appears to lie in a closer study of what actually happens as the boiler water traverses those surfaces where steam is generated. Here the water must absorb heat from the boiler tubes which receive it from furnace temperatures of 2000 to 2500 degrees, Fahrenheit, and must pass it on fast enough so that the temperature of the external surfaces of the tubes will not exceed 800 to 900 degrees, Fahrenheit.

CONCENTRATION OF SALTS—As steam bubbles form on the heating surfaces, the question arises as to whether the film of boiler water concentrating around the bubble will evaporate to dryness and deposit its salts in solid form on the tube surface.

To resolve the question of deposition of concentration of salts under the steam bubble, it is necessary to know whether the overheating at the tube surface is sufficient to raise the temperature of the boiler water at the interface between steam and water above the boiling point of a solution saturated with respect to any of the salts present. If the temperature of the film at the interface is greater than the boiling point of a saturated solution of one of the salts present, then to establish equilibrium that salt will start to deposit. Consider, for example, the behavior of sodium chloride, potassium chloride, and sodium sulfate in a boiler operating at 1800 pounds per square inch. The boiling points of saturated solutions of these salts (at 1800 pounds per square inch) are 692, 745, and 625 degrees, Fahrenheit, respectively. The overheating which would result in deposition under steam bubbles in an 1800 pounds per square inch boiler (boiler water temperature 621 degrees, Fahrenheit) would be 71, 124, and 4 degrees, Fahrenheit, respectively. In other words, if the overheating was 10 degrees, only sodium sulfate would deposit, while, if it was over 71 degrees, Fahrenheit, both sodium chloride and sodium sulfate would deposit, but potassium chloride would not begin to deposit until the overheating exceeded 124 degrees, Fahrenheit.

The significance of this approach to high-pressure boiler water problems lies in the fact that once sufficient data have been acquired, it will be possible to predetermine whether a boiler water on concentration will finally become saturated with one or all of the salts present and then, by adjustment of the relative concentrations of these salts, to force the solution to behave as desired.

One of the first fruits of this study has been the unexpected discovery that many potassium salts behave much more favorably than the corresponding sodium salts. It has also become evident that proper control of boiler water will permit concentration of other salts simultaneously with caustic, thus inhibiting alkali attack whether it results in embrittlement or becomes a contributory factor in corrosion by bonded oxygen.

It is necessary to emphasize again the fact that the chemistry of boiler water is a constantly developing science in which many able research men are co-operating with boiler designers and operators to give the latter the greatest possible latitude in design and operation for increased economy. Developments in this field may radically affect marine boiler design in the future.

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POLARIZER

Uses Large Sheets To Good Advantage

EXAMINATIONS by polarized light to reveal strains in structures of various kinds can now be more conveniently made in a new instrument embodying Polaroid sheets. The polarizing sheets are mounted separately between glass plates and so arranged that one is stationary over the light box while the other can be moved through eight inches parallel to it. The plates are about 12 inches square, which contrasts with the calcite prisms of less than a square centimeter in cross section that were formerly available.

X-RAY ABSORPTION

Gives New Tool to Chemical Analysis

SHOOTING a beam of X rays through an unknown substance and measuring how much of the radiation is absorbed thereby is a rapid means of chemical analysis recently developed. The method, which can be used with gases, liquids, or solids, hot or cold, is expected to find extensive application.

X-ray absorption as an analytical method is made practical by a photoelectric X-ray intensity meter developed in the General Electric Research Laboratory, where the method was developed. The invisible X rays fall on a fluorescent material, which becomes luminous where they strike. This material, called a phosphor, is painted on the glass envelope of a phototube of the multiplier type.

With such a tube the light from the phosphor falls first on a sensitized surface within the tube and electrons are emitted. These electrons fall on a second surface from which still more electrons, in larger quantities, are discharged. They fall on a third surface and the yield is still further increased. Then even more stages are used. Thus the electrons are multiplied and those from the last stage result in a small electric current which can be amplified still more with other electron tubes, and measured with an appropriate meter. Amounts of light with energy equal to only one ten billionth of a watt can be measured easily and accurately in this way.

The photoelectric meter can measure very weak intensity X rays and also can detect extremely slight variations in their intensity. For example, if the X rays are passed through a pile of 100 sheets of paper, the difference in absorption caused by the addition or removal of a single sheet produces a noticeable effect.

In the analytical method, which has thus far been set up only experimentally, the solid or liquid sample is placed in a glass cell ¾ inch in diameter and 6 inches long. For gases a two foot cell is employed. The current from the phototube is amplified and its intensity read on a meter. Comparisons are made of the absorption of the cell with and without the sample.

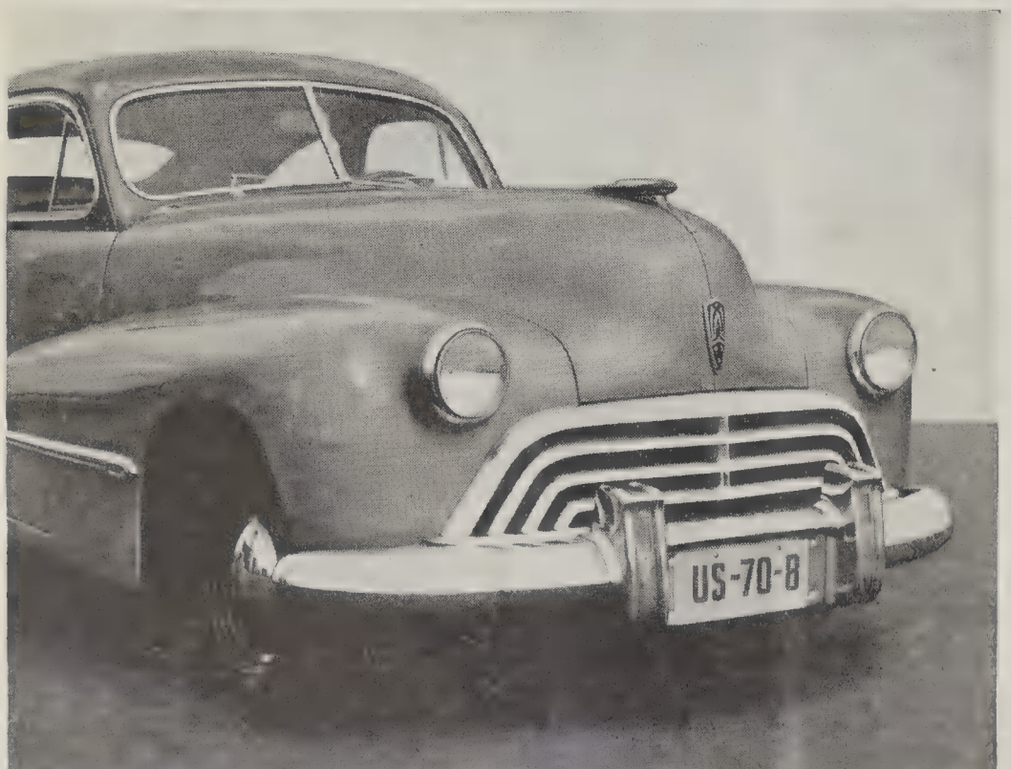
Motor Cars Tomorrow

Rear-Engine Vehicles are Possibilities, but Most of the Radical Changes in Motor Cars are Still in the "Air Brush" Stage. Inroads of Foreign Cars are not Feared, and a New Drive is on to Popularize Small Cars. But the "Big Three" Will Probably Have the Last Word

ALTHOUGH most of the automobiles which are already in production and which will be coming off the assembly lines within the next few months will be only slightly revised editions of 1942 models, Detroit and other automotive centers are seething with rumors of radically different designs. Reason for few changes in the large production models is because the industry is just as anxious to get, and collectively probably more interested in getting, into production than are prospective new car owners. Any basic or radical change would delay getting cars into the hands of the manufacturers' dealers.

At the moment it appears that anything as radical, for example, as moving the engine to the rear of the car will be left to the more fanciful newcomers into the business. However, the possibility of the combination of the reputation of Graham-Paige and the dramatic name of Henry Kaiser might have some hand in a fairly early introduction of a rear-engined car. A version of William B. Stout's "Scarab" is likely in this combination since Mr. Stout has been retained by the Graham-Paige Corporation, as a consulting engineer. He is the country's leading exponent of this design.

Joseph W. Frazer and Mr. Kaiser have announced the formation of the Kaiser-Frazer Corporation, the idea being that the dynamic west-coast dam, bridge, highway, and shipbuilding executive may have an automobile named after him. Mr. Kaiser's steel and light-alloy facilities, marine propulsion, and other engineering interests make his pronouncements about the car of the future something with which to conjure, particularly because of his faith in the unbounded future of the west. He will probably make every effort to establish whatever peacetime industries he can to absorb his steel and light-metal production. His notable record for war production, and his excellent reputation as a doer of big things before the war, augurs well for some interesting news from his direction.



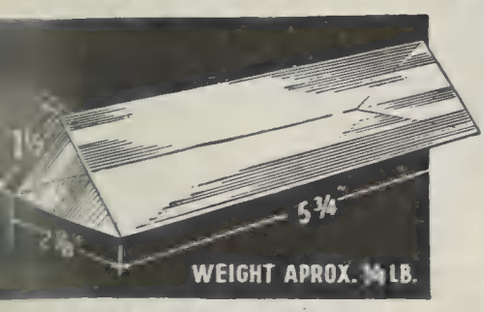
General Motors' Oldsmobile for 1946

WHAT PUBLIC WANTS—The American motor-car buyer has demonstrated that a large package and good looks are more to be desired than a smaller and more economical vehicle, although the Willys-Overland "de-militarized" Jeep is expected to have a great popularity as a farm and industrial utility vehicle. No car has ever had such favorable public acceptance as the Jeep, and numberless stories told in words and pictures, have made Jeep a household name throughout the world. All of this good will can be counted upon to help merchandise this vehicle.

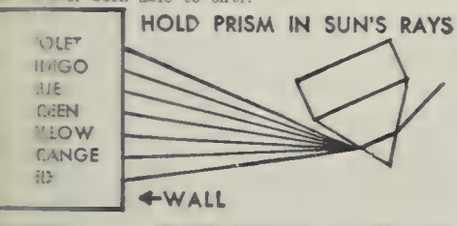
Apparently Powell Crosley, Jr. thinks there is a good market for small cars in the United States. He recently sold the controlling interest of Crosley Corporation to Aviation Corporation, with the exception of the automobile division. He announced that the post-war Crosley car will be a few inches longer than the pre-war model, and will be powered by a four-cylinder instead of a two-cylinder powerplant. But gasoline consumption and the total weight of the car will be about the same, he estimated. He is gambling against the "large package" boys.

Few Detroiters fear the inroads of British automobiles, which are already in production. Despite reports to the contrary, British and European manufacturers have failed to grasp the economic advantages of mass production to the extent that American manufacturers have

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It's easy to remove the silvering from a silvered prism to make an interesting experiment. Hold prism in sun's rays as shown in drawing. White incident light which passes through prism is thus broken up into a band of primary colors known as the spectrum—a beautiful sight! By looking through a tank prism at a certain angle, you can see a world of colors everywhere. Truly amazing!

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RETICLE SET . . . Five assorted, finely engraved recticles from U. S. Gunsights. Among others contains ■ Cross Line Reticle with perfect pin point hole in center. Very useful to astronomical mirror makers for testing. Worth several dollars each.
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ACHROMATIC TELESCOPE OBJECTIVE LENS . . . Diam. 48 mm., F. L. 11 inches. Edged but not cemented.
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4009-S	Heat Absorbing Glass 4" ■ 5". Each	.35
4010-S	Heat Absorbing Glass 2" ■ 2". Each	.10
2020-S	40 mm. Neg Lens, Cross Lines. Each	.25
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6078-S*	33	140	Uncemented	70c
6081-S*	35	55	Uncemented	70c
6082-S*	37	57	Uncemented	70c
6084-S*	41	66	Uncemented	70c
6085-S	45	135	Uncemented	$1.00
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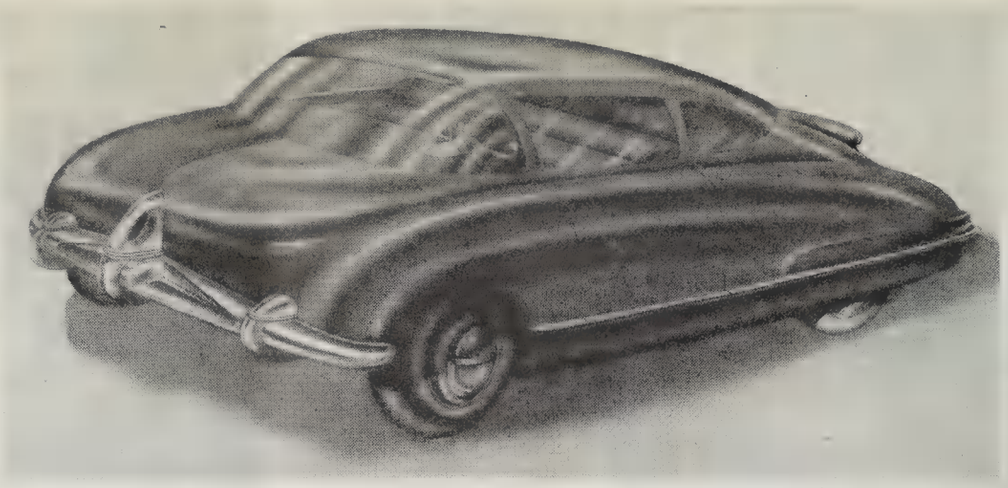
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done. The result is that, even in the face of lower hourly wages, these British and European vehicles are more expensive than low priced American automobiles. Several months ago materials for the British motor-car industry were released by that Government, and some of the plants, such as Austin, are in full production. The American market will probably absorb all the British cars that are offered, for a while, in spite of a high price. But as soon as the "big three"— Chevrolet, Ford, and Plymouth—and others in the low and medium priced fields, get into production at pre-war volume, imports of foreign cars are expected to fall off rapidly.

The next important change in power-plant design apparently will be a combined reciprocating internal combustion engine hooked up with a high speed turbine, the latter to turn the former's exhaust gases into propulsive power. A great deal of experimental work has been done on this type of engine, but little has been divulged about it publicly. Not long ago several Army Ordnance and Navy officers discussed its possibilities, but feared that not enough work has been done to expect that such an engine would get into early production. However, development work is continuing.



Ray Russell, industrial designer, conceived and built this Quadratic Drive car with rear engine. A hydraulic system eliminates the clutch, transmission, drive shaft, universal joints, differential, rear axle housing, axles, and brakes. The engine drives a multiple hydraulic pump of variable pressure capacity. This pump forces hydraulic fluid through flexible couplings to all four wheels, in each of which is mounted a hydraulic motor. Braking power is applied through regulation of the speed of the hydraulic fluid moving through the motors. The builder of this car (which is not yet in production) claims 12 percent cheaper operation than other cars of similar weight

HIGHER EFFICIENCY—In general, automotive engineers appear to be satisfied with the present internal combustion engine. However, there are some exceptions and men such as C. F. Kettering, head of General Motors' far-flung research projects, think that only the surface of the problem of more efficient engines has been scratched. "Boss Ket" envisions not only new fuels, but a better understanding of fuels by engine designers, and a better matching of fuel characteristics to the engine of tomorrow.

But automotive engineers everywhere are expecting considerable improvement in motor-vehicle transmissions. The fluid flywheel brought out by Chrysler, and Oldsmobile's "hydra-matic" automatic transmission, are held by a number of men to be only the beginning in improving the power-transmission link between engine and rear axle. At least a dozen organizations are working on this problem, and several engineers have concluded that simpler automatic gear shifting will be justified by popular demand even if the actual efficiency in operation takes a setback.

A wealth of developments in power transmission, ideas which have been borrowed from such industries as the machine tool and industrial power transmission, form an interesting background for vehicle transmission improvements. Although the basic principles of hydraulics have been long known, some of the newer control valves and actuating mechanisms open interesting possibilities to men who are devoting their whole attention to this phase of automotive engineering.



Fords for 1946 come off the production line

RUBBER—Better understanding of synthetic rubbers, and greater experience with the more resilient types, have opened new engineering vistas in car, bus, and truck chassis suspension. Here, as in the case of new fuels and matching new engines to them, is a field where the chemist and engineer must work together closely. Off-the-record opinions about the future of the synthetics as an engineering material are glowing. Few chemists or engineers who have been working with these new materials are willing to be quoted at this stage of developments because of the lack of experience. What has been discovered to date, however, leads many an automotive engineer to envision radically different suspension in the interest of more rider comfort. The fact that large amounts of money are flowing into these researches

indicates that management has faith in synthetics.

The top executive of one of the world's most important tire companies predicts tires that will last as long as an automobile, won't puncture, blow out, or even skid on wet pavements. He expects to see the day when a tire can be expected to run 100,000 miles.

Just as the airplane shock strut development borrowed heavily from automotive shock absorber experience and the considerable amount of research it involved, so will vehicle designers borrow from current experience of aircraft engineers who have multiplied the knowledge developed in this field.

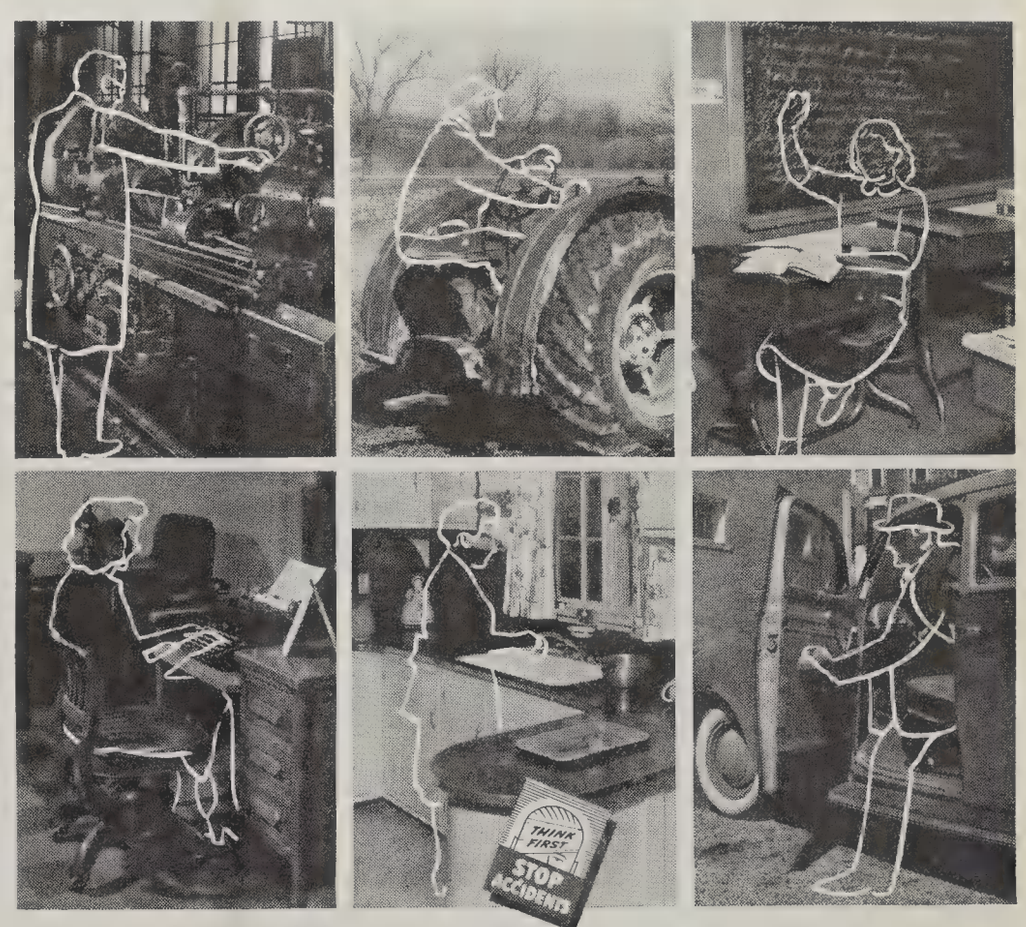
METALS—The art of metal working has been making rapid strides while production men have been sky-rocketing output of guns, shells, and the thousands of mechanical devices needed to win a war. Just before the war, the age-old idea of peening surfaces found vigorous proponents, and shot peening of working parts has come into its own. Surface stresses, often increased by grinding and polishing, are relieved by shot blasting. As a result of extensive laboratory work and actual production of parts, a vigorous school of shot peening or shot blasting advocates is showing remarkable improvements in the fight against fatigue of metals. Fortunately for the motor car owner of the future, much of this work has been done in automotive factories. Ford, for example, will offer shot-peened engine valve springs, which will also be rust proofed.

The improvements in other metalworking techniques are almost endless. Better controls of heat in heat-treating operations, better controls of alloying processes in the steel mills, greater knowledge of the nature of the metals as well as of the tools and grinding equipment, more experience in machining and forming aluminum and magnesium, and even the vast experience in manufacture of plastics-impregnated wood and canvas, are being counted upon to have an important part in shaping the future of the motor car.

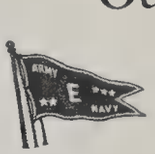
Most informed engineers do not expect extensive use of aluminum sheets in car bodies, leaving that field of speculation largely to the "air-brush" designers. It is probable, however, that a good deal more aluminum will be used in engine castings than ever before. Continental and other engine builders are developing several models of engines using more cast aluminum than was used in prewar days. The new Fords will substitute aluminum for steel pistons, both in the six and in the eight, as well as in the new edition of the eight-cylinder truck power-plant.

RESEARCH—Although the huge General Motors Technical Center to be built in the environs of Detroit and the great engineering and research departments of Chrysler and Ford are extremely impressive as facilities for engineering developments in the automotive industry, there is in addition some 150 millions invested in other motor vehicle and parts research and development laboratories and proving grounds in the United States. Suppliers—notably steel mills, nonferrous, rubber goods, chemical, and petroleum manufacturers—apply a sizable share of their total research effort and expenditures to automotive problems.

As a matter of fact, a large percentage of the actual development of improved automotive devices are attributable to the parts and supply industries which serve the vehicle manufacturers. Often development work is done jointly by the supplier and a prospective customer. A number of projects of this general scheme are getting into high gear.



Out of action... *because they didn't see*



More than 350,000 deaths, 1,300,000 permanent disabilities suffered since Pearl Harbor—more than the total of all casualties caused by enemy action—are *due to accidents* in traffic, at home, on the farm, at work. One reason for this appalling toll on needed manpower is faulty eyesight.

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Atomic Bombs

Power of Devastation Lies in Disruption of the Atom by Methods Not Yet Completely Revealed. However, Research Progress, Reported Before the Entry of the United States into the War, Indicated the Paths Along Which Intensive Work Has Been Done Both Here and Abroad

By A. P. PECK

EDITOR'S NOTE: Admittedly, world security prevents publication of detailed information on the atomic bomb which rocked Japan early in August, and likewise rocked the scientific world and the world of the man on the street to its very foundations. The newspapers have done an adequate job of guessing about the principles of the atomic bomb and about the possibilities of atomic power in the future. The accompanying article, composed mainly of excerpts from issues of Scientific American, gives about all of the specific data available today and points the way to the future.

WHEN the first atomic bomb burst over Japan, it did far more than disintegrate the homes, the industries, and the very bodies of the Japanese within a range far greater than had ever before been reached by any man-made explosion. It proved that man had at last solved, in a limited measure, the means of unleashing the locked-up power of the atom and putting it to work. That such power for good or evil lies in the very atoms which are the basis of all matter has been known for many years. But mere knowing has failed to furnish the key. The road to knowledge has been long and rough. Even now that atomic bombs have proved themselves, there remains much work ahead.

Can the power of atomic energy be put to useful purposes? The answer is that it can but that the means of so doing will probably involve more intensive and extensive research than has already gone into the development of the atomic bomb itself.

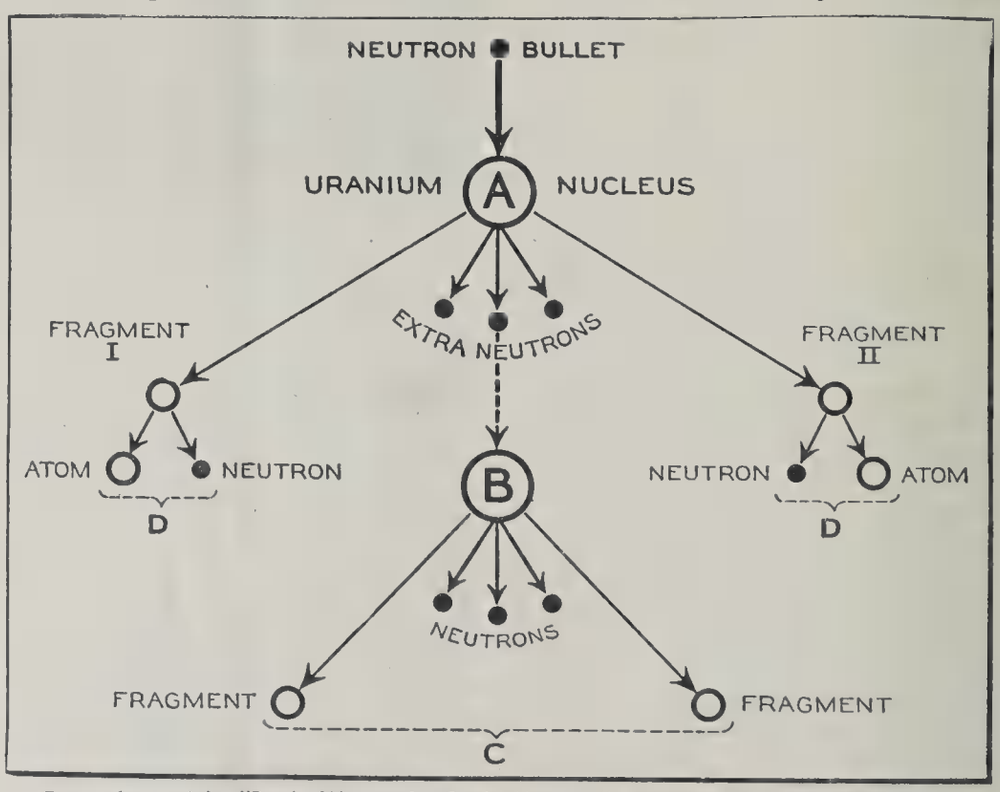
Details of the atomic bomb cannot—and should not—be revealed to the public. However, some insight into the background of atomic power is permissible and can be obtained from back issues of Scientific American. To supply such information on a sound basis, free from the hysteria that understandably characterized the first reports of the atomic bomb in the daily press, the main body of this article is composed of direct quotations from Scientific American. Dates are given so that those interested in seeing the complete articles can easily locate them.

URANIUM SPLIT—The first interpretive article, in an unconnected series that ended when censorship rightly clamped down on atom-splitting articles, appeared in Scientific American for October 1939. In that issue, Jean Harrington, writing under the title "Two Elements for One," had the following to say:

"The Fifth Washington Conference on Theoretical Physics was sitting in solemn conclave when the news broke. Professor Nils Bohr of Princeton and Professor Enrico Fermi of Columbia rose to open the meeting with an account of some research going on in a Berlin laboratory.

"It was January 26, 1939. A few weeks before, at the Kaiser Wilhelm Institute in Berlin, Dr. Otto Hahn, a distinguished German physicist, had obtained an utterly unexpected result from more or less routine experiments. Following the original example of Professor Fermi, Dr. Hahn and his co-worker, F. Strassmann, had for many months been bombarding uranium with neutrons and studying the debris left by this atomic warfare.

"It was news, and big news, to discover barium among the debris —barium, which is only a little more than half as heavy as uranium.



From the article "Don't Worry—It Can't Happen," published in May 1940 issue, Scientific American. Diagram of a theoretical chain reaction for uranium. The neutron bullet at the top splits the uranium nucleus *A* into fragments I and II and, in addition, erupts three extra neutrons. One of the latter may hit another uranium nucleus *B*, and split it into similar fragments and neutrons *C*. Each of the first two fragments may break down into another atom plus a neutron, as shown at *D*, left and right

It meant that the neutron bullets had succeeded not merely in knocking a few chips off the old block, but in blowing the whole atom asunder with a terrific explosion.

"A few insiders had already jumped the gun ahead of the Conference and of the rest who learned of the discovery through the newspapers. In Copenhagen, Dr. O. R. Frisch and Professor Lise Meitner, who had previously worked with Hahn on the same problem, had verified his results ten days earlier. A group of Columbia University physicists, including Fermi, independently thought up and carried out a similar experiment by January 25, the day before the Conference. By the time the meeting wound up its affairs January 28, three more laboratories—at the Carnegie Institution of Washington, Johns Hopkins, and the University of California—joined the chorus of confirmation. In a word, Hahn was right. Uranium, and thorium, too (thorium is also among the heaviest elements), had been split in two by neutron bombardment.

"The phenomenon was quickly dubbed 'nuclear fission,' and in the months ensuing since its discovery, nuclear fission has grabbed the spotlight from the 'heavy electron' sensation of 1937-8. Dozens of the world's top-flight physicists have been busy as bees, roaming the clover of a new field of research.

"In a discovery like this in the realm of pure science, it is always easier to see the theoretical importance than to find a practical application. The fission of uranium has provided a field day for the physicists who like to take atoms apart and find out what makes them tick. It adds a new chapter to their knowledge of the nucleus—the forces that hold it together, the collective behavior of its constituent parts, its reaction 'under fire,' its destiny.

"Our imaginations are immediately seized by the terrific amount of energy liberated when a single uranium nucleus explodes. The two fragments fly apart activated by some 200,000,000 electron volts—a total far greater than that associated with any other atomic phenomenon except cosmic rays.

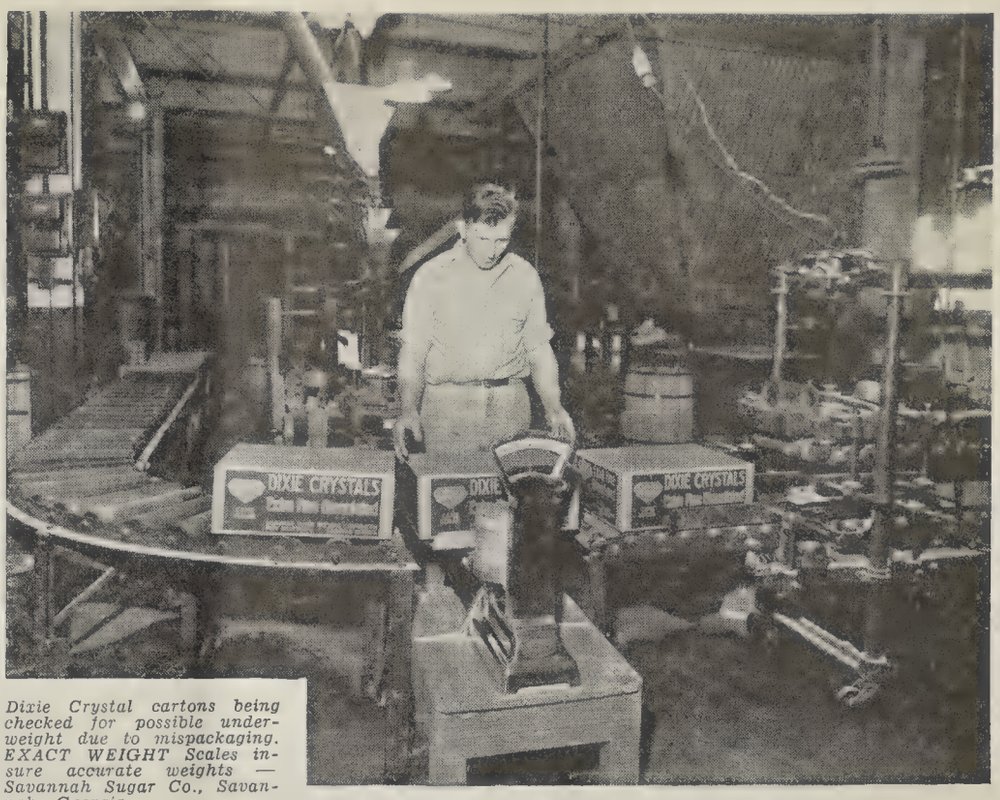
"The tabloids love to write of blowing up the world with a gram of matter, and it's not such a sensational idea as one might think. Even a tiny mass has an enormous potential of energy if it could but be freed. It is just such a conversion of mass into energy that speeds the fission fragments on their way.

"Of course, 200,000,000 electron volts is an astounding energy compared with the size of the bodies which possess it. But for practical purposes it is absurdly small, amounting only to about three ten thousandths of an erg. In more everyday terms, it would take 25,000 billion fissions per second to produce one horsepower — figures which dwarf even the national budget. The very best a laboratory can do so far is to produce a few hundreds per second.

"If atom smashing could be made more efficient, power production by means of nuclear fission would not be beyond the realms of possibility.

"Research along all these lines is proceeding at breakneck speed. Experiments similar to those with uranium have been performed on thorium with similar results, except that only fast neutrons are effective in splitting the thorium nucleus, while both fast and slow work well on uranium. Other heavy elements, such as gold and tungsten, show some slight tendency to undergo fission.

"It is probable that a sufficiently large mass of uranium would be explosive if its atoms once got well started dividing. As a matter of fact, the scientists are pretty nervous



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over the dangerous forces they are unleashing, and are hurriedly devising means to control them.

"It may or may not be significant that, since early spring, no accounts of research on nuclear fission have been heard from Germany. It is not unlikely that the German government, spotting a potentially powerful weapon of war, has imposed military secrecy on all recent German investigations. A large concentration of isotope 235, subjected to neutron bombardment, might conceivably blow up all London or Paris."

END OF THE WORLD?—If the energy locked in the atom could be released, why would not that energy release the power in other atoms and start a long chain of reactions that would result in a practically instantaneous end of the world? All atoms hold tremendous locked-up power. Granted that atoms of uranium and thorium are the only ones which thus far can be directly unlocked, why would not the released energy be enough to start other atoms off and disrupt the entire universe within a split second?

Miss Harrington, writing in the May 1940 issue of Scientific American, in an article entitled "Don't Worry—It Can't Happen," showed that the action of the atomic power of uranium can be controlled. Perhaps the title of the article exerted a soothing influence on the Japanese. In any event, it *did* happen, but in a different way than the article title indicated. Here are the important points that Miss Harrington made:

"Just about a year ago, physicists who had been gunning at the metal uranium with neutron bullets, just to see what would happen, suddenly found that they had caused the biggest explosion in atomic history. It wasn't a big explosion in an everyday sense; no Berlin window panes rattled at the blast, and no one heard the noise. But it seemed big and loud enough to other physicists all over the world. They had never before known of an atomic blast of such tremendous energy, and presently they began to worry about it.

"Previous experiments had succeeded only in knocking chips off atomic nuclei, and these operations released only a tiny fraction of the boundless energy locked up in atoms. But, when uranium cracked in two, 200,000,000 volts of energy burst forth in the form of radiation, heat, and speed.

"It was soon apparent that quite a number of strange and wonderful things happened when the uranium nucleus blew up. Besides the two main fragments, a few spare neutrons (two or three per fission) were thrown off from the original nucleus. In addition, the two new atoms were unstable, erupting neutrons and other particles in a whole series or chain of reactions until they finally subsided. The result was a great hodge-podge of new atoms and extra neutrons.

"In the midst of all this research, a chilly sensation began tingling up and down the spines of the experimenters. These extra neutrons that were being erupted—could they not in turn become involuntary bullets, flying from one exploding uranium nucleus into the heart of another, causing another fission which would itself cause still others? Wasn't there a dangerous possibility that the uranium would at last become explosive? That the samples being bombarded in the laboratories at Columbia University, for example, might blow up the whole of New York City? To make matters more ominous, news of fission research from Germany, plentiful in the early part of 1939, mysteriously and abruptly stopped for some months. Had government censorship been placed on what might be a secret of military importance?

"The press and populace, getting wind of these possibly lethal goings-on, raised a hue and cry. Nothing daunted, however, the physicists worked on to find out whether or not they would be blown up, and the rest of us along with them.

"The key to the problem is probably the speed of the neutrons. In the original experiments it was soon found that relatively slow neutron bullets were the most effective in producing fissions. As the chain reaction proceeds and more and more energy is released, the uranium target becomes heated. The extra neutrons are perhaps so speeded up by the heat that they cease to be efficient atom-busters. Thus the reaction poohs out as the temperature rises."

ATOMIC POWER—In July 1940 the article "Is Atomic Energy Nearer?" by Roy C. Copperud of the University of Minnesota, detailed still other research and gave still another lead to the atomic bomb of today and atomic power of tomorrow. The following excerpts from that article are significant:

"Eyes of the scientific world widened the first week in May at the startling news that work of a 28-year-old physicist at the University of Minnesota, Dr. Alfred O. C. Nier, in isolating the explosive uranium isotope, U-235, had been corroborated, marking a significant advance toward shackling atomic energy.

"There were predictions that this discovery made feasible bombs of unheard-of strength, that five or ten pounds of U-235 would propel a vessel around the world for an indefinite time without refueling—in short, that economic foundations of the world were about to crumble.

"The fact of the matter, he insists, is that many a knotty problem remains to be solved before any useful harnessing can take place. Chief among these is extraction of U-235 in vastly greater quantities than is possible now.

"Dr. Nier estimates that one pound of U-235 would generate as much force as the combustion of 2,000,000 pounds of coal, or that its detonating energy would be equivalent to that of 20,000 pounds of high explosives.

"Dr. Nier estimates that, even with any reasonably economical means of extracting U-235 in large quantities, the cost per unit of energy produced would equal that of coal. 'So you see,' he observed, 'it would not mean getting power for nothing.' Despite the extraction cost, the great amount of energy concentrated in a small volume would make it invaluable for airplanes, for example, or any other apparatus where weight of fuel is a consideration.

"The Minnesota scientist considers it hardly likely that the mass spectrometer, the device he used to separate the uranium isotopes, can be adapted to mass production. It is more probable that some chemical means of separation would turn the trick. But as to any such method, researchers are still at sea. Dr. Nier emphasized further that, once extraction is accomplished, the problems of handling and chaining the atomic force safely might occupy scientists for years.

"This is the abbreviated story of what may well prove to be one of the great crests of scientific achievement. True, researchers are cautious about advancing ambitious claims, and Dr. Nier himself believes that remaining obstacles to chaining atomic power will persist far into the misty future. But only ten years ago it was considered impossible to separate the isotopes of any element whatever, and now it is being done commercially with hydrogen."

WHAT IT ALL MEANS—The curtain of censorship falls. Work on the power of the atom becomes too important to spread in the public press. Military supremacy of the world, more important at the

moment than anything else, is at stake. Despite the jump that Germany apparently had on the rest of humanity in this matter, the events of early August 1945 showed clearly that the final answer was found in the United States. An atomic bomb spread devastation. Then another. The Japanese learned what "all out" war meant. The power of the atom had been put to man's use, but unfortunately to a destructive use. What man can harness to one purpose, he can control to another. But when?

The atomic bomb poses many questions. It has proved that atomic power can be used. When will atomic fission drive automobiles and airplanes, replace coal and oil for power generation, make water power obsolete? We can only be honest and say that we do not know. The time is closer than it was five years ago, and not only because of elapsed time; concentrated knowledge has bridged a generation in atomic power development. It is probable that someday, perhaps within the lifetime of many present readers, a spoonful of uranium or some similar material will replace a binful of coal or a tank of oil in the cellar; that automobiles will be made with a life-time of fuel sealed in; that power-plants will be independent of fuel as we know it today. But until more details are available—and that time is apparently far distant—we will go along with Mr. Copperud and say: "Many a knotty problem remains to be solved before any useful harnessing can take place."

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FOOD PROCESSING

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Food scientists are calling upon the latest findings in the field of electronics to aid in conserving the nutritive value of vegetables during processing for dehydration or freezing preservation.

By using high-frequency electricity for blanching vegetables in place of flowing steam or boiling water, food chemists at the New York State Experiment Station reduced the loss of vitamin C in treated raw cabbage from the 30 to 40 percent occasioned by the usual blanching methods to only 3 percent by electronic blanching.

Commenting on their experiments, the Station workers say: "For their successful preservation by freezing or dehydration, vegetables are briefly exposed to flowing steam or boiling water. This heat treatment inactivates enzymes which may cause deterioration of flavor and destruction of vitamins during storage. However, these heat treatments sometimes damage the texture of the vegetables, making them soft, and the steam or boiling water also leaches out vitamin C and some of the B complex vitamins, thus reducing the nutritive value of the food.

"It occurred to us that electronic heat might be used in place of steam or boiling water, with improvement in the texture of the treated product and reduction in losses of vitamins. It was thought that by using high-frequency electricity, washed fresh vegetables could be placed directly in the container which goes to the consumer, passed through a high-frequency field to inactivate the enzymes, and then directly into the freezer. This would eliminate much handling and possible contamination of the vegetables before they reach the consumer. The results obtained from the electronic heating of cabbage have led to more extensive tests with other vegetables. While our experiments have been on a small laboratory scale, it is possible that rapid advances in electronics during the war may make possible the large-scale use of electronic heating in the commercial processing of fruits and vegetables in the not far distant future."



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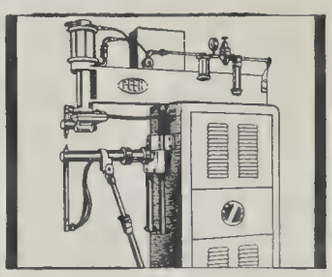
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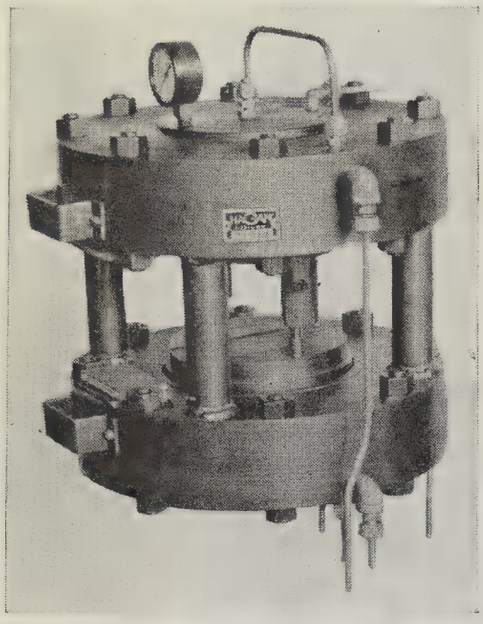
Z-82

New Products and Processes

FORCE MEASUREMENT

Instrument Uses Air-Loaded Diaphragm

MEASURING and weighing with air, with such accuracy and sensitivity that the force of a pea from a boy's pea-shooter or the thrust of a giant jet airplane engine can be measured, has been accomplished by a new instrument



Accurately measures force of a pea-shooter or the thrust of a jet engine

called the Thrustorq. It already is being used in engine testing laboratories and factories to determine and record the thrust and torque of conventional airplane and automobile engines. A jet airplane engine manufacturer is using the instrument to measure the thrust of a new engine.

The heart of the Hagan Corporation's instrument is a flexible diaphragm which forms one face of an airtight chamber. Compressed air is admitted to this chamber through a poppet type pilot valve. The force to be measured is applied to the outside of the diaphragm and is opposed by internal pressure. As the force increases the pilot valve is opened and admits more air to balance the increased force. As the force decreases, air is exhausted until the external force and internal pressure are equal. Thus the air pressure within the chamber provides a direct measure of the externally applied force.

The response of the instrument is practically instantaneous because the diaphragm movement necessary to operate the pilot valve is extremely small.

Because the force is measured by air pressure, the Thrustorq permits remote reading on any number of manometers, pressure gages, or recording devices. Every person connected with a test may have his own recorder in front of him, even in a different room or different building from that in which the test is being made.

Although the Thrustorq's first application in industry was the obvious one, to measure the thrust and torque of engines, its characteristics have suggested many other uses. Because of its compactness and the fact that it requires almost no deflection to provide a reading of force, the unit can be used to analyze many structural stress and strain problems.

FORMING PAD

Made of Synthetic Rubber For Magnesium Forming

PRODUCTION of magnesium sheet metal parts for industry will be speeded as the result of the development of a new heat-resistant synthetic rubber forming pad announced recently by the United States Rubber Company.

The pad is a solid chunk of synthetic rubber weighing 2800 pounds and measuring 116 inches long, 50 inches wide, and eight inches thick. It is used as the female die in hydraulic presses to form heated magnesium under 5000 tons of pressure. When compressed, the rubber transmits the full pressure of the hydraulic ram against the sheet, flowing into all irregularities and forcing the metal into the desired shape. When the pressure is released the rubber returns to its original form.

Since the beginning of the war the United States Rubber Company has made many rubber forming pads for cold forming aluminum. These pads were not suitable for shaping magnesium, however, because the magnesium tends to be brittle when cold and does not respond to forming without heating. The synthetic rubber pad, the first one of its kind, will withstand the temperatures up to 450 degrees, Fahrenheit, required by the process. In addition to being heat resistant, it is built to stand severe flexing and long wear.

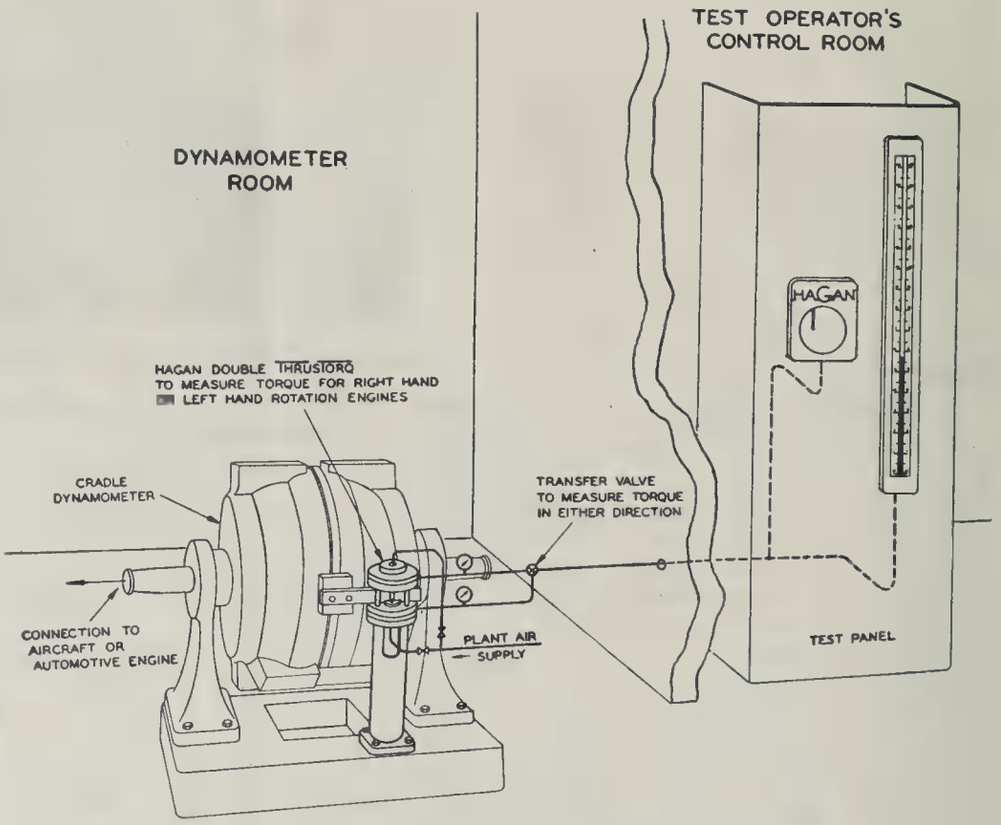
HARDNESS TESTER

Facilitates Testing Without Taking Specimen

AN INSTRUMENT that makes practical the taking of an adequate hardness test right where the material is—in the shop or yard, on the truck or car—anywhere it may be, instead of taking a specimen to a testing machine, announced by Steel City Testing Laboratory, is identified as a Portable Hardness Testing Hammer Type "P".

In many cases it is not necessary to obtain a scientifically accurate test of a material, but it is sufficient to know the hardness in regard to workability. With this self-acting hammer, such tests can be made quickly, employing unskilled labor. Repeated tests can be made without readjusting the hammer.

If material of a certain degree of hardness is to be selected, it is only necessary to see whether the diameter of the impression made corresponds



A typical force measurement installation, with remote control room

to the desired degree of hardness. If the impression is smaller or larger, the specimen is either too hard or too soft.

The hammer consists of a cylindrical housing and easy moving piston; one end of the housing is closed with a cover and the other end is provided with an open bushing. Between the cover and the piston, a strong spring is located which presses the piston against the bushing. The tension of the spring can be adjusted by turning the cover, to set the hammer to a certain power of stroke. The piston is coupled with a striking bolt, which projects through



A portable instrument for making hardness tests. It does not require the services of a skilled operator and may be taken direct to the location where tests are to be made

the bore of the bushing, guided by an airtight fitting ring in the cylinder, and carrys a steel ball on its end.

Resting the hammer with the ball against the material to be tested and pressing on the operating end, the striking bolt and the piston in the housing move inward and press against the spring between the piston and the cover. At a certain point in this movement, the coupling between the piston and the striking bolt is released, so that the piston, under pressure of the spring, moves quickly against the inner end of the striking bolt and forces the ball against the material to be tested. After the hammer is released, the striking bolt is brought back to its former position by a spring.

PLASTICS PLATES

Can be Permanently Applied To Any Surface

A GUMMED plastics plate that will adhere to and make a permanent bond with any clean surface when moistened with a solvent such as benzine, naphtha, and so on, presents unlimited applications. An identification plate can now be permanently attached to any object with a clean surface without using screws or other usual methods of attaching plates.

Everclear "Everstick" Plastics Plates, made by Pennsylvania Plastics Corporation, are the result of three years of research to develop a cement that could be applied to the back of plastics plates and dried to facilitate easy handling. When the plate is ready to be applied it is reactivated with a common solvent of the type mentioned above and forms a permanent bond with the surface to which it is applied.

The advantages of Everstick Plates include a permanent bond; adherence to any shape or curved surface; more durability than a decal; elimination of drilling, screws, and drill jigs; adhesion that is not affected by weather conditions, unlimited range of color; permanent color; availability with fluorescent and phosphorescent letters.

SOIL TESTER

Operates on Principle of Electrical Conductivity

FOR MANY years it has been known that the electrical conductivity of soil extracts accurately indicates the soluble salt or fertilizer content of the soil. In the past, however, the equipment necessary for such tests has been elaborate and delicate, and not adapted to the needs of the greenhouse.

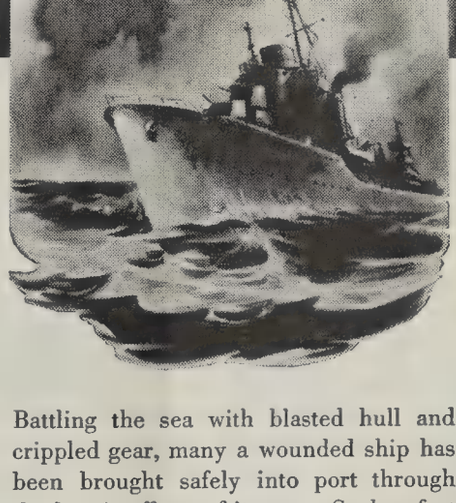
Now a compact, sturdy, low-cost, easy-to-operate instrument, the Solu-Bridge soil tester, is available, built specifically for soil workers. The soil tester was designed to fill the growing need of soil workers and greenhousemen for a practical instrument to measure the electrical conductivity of soil extracts, particularly greenhouse soils.

The Solu-Bridge soil tester is a self-contained A. C. Wheatstone Bridge, employing a cathode-ray tube to indicate the point of balance, and operating directly from the power line. A temperature compensator is incorporated to eliminate the need for computation.

To make a measurement, a sample of air-dry soil is mixed with twice its weight of soft water, shaken for a minute or two, and the coarse particles allowed to settle for a few minutes. The solution is then poured into a clean vessel, its temperature checked with a thermometer, and the temperature compensator is set to that value. The conductivity cell is dipped into the extract and the main dial turned until

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Battling the sea with blasted hull and crippled gear, many a wounded ship has been brought safely into port through the heroic efforts of its crew. Such a feat calls for cool heads and fast work—for skilled hands and the right tools. Equipment must be equal to the emergency; accuracy and speed are absolute requirements. Machines, as well as men, must deliver unfailing performance.

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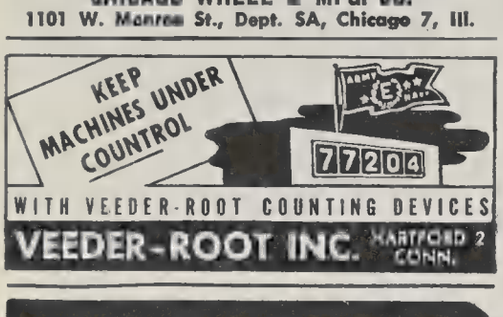
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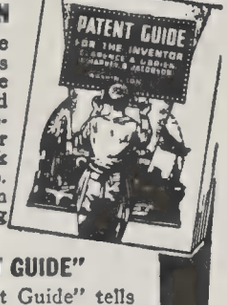
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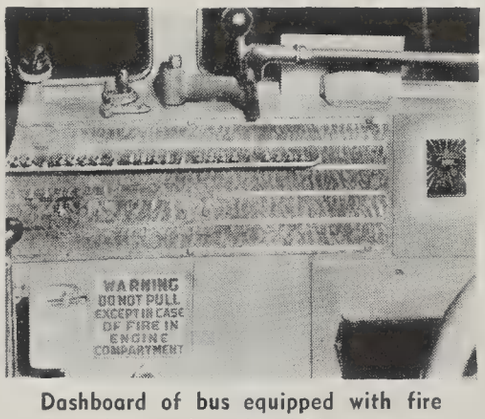
balance is shown, whereupon the specific conductance is read directly from the scale. No calculations whatever are necessary.

Soil extract conductivity measurements have been used to maintain optimum fertility conditions during the germination and growth of many vegetables and flowers, including tomatoes, roses, radishes, carnations, and so on. It has been found that the growth rate of these and other plants is very sensitive to total fertilizer content, and that budding and blooming time can be controlled through this means.

BUS FIRES

Extinguished by Rapid-Acting System

In a new built-in fire-extinguishing system for the engine compartment of buses, fire detection occupies first place. Specially designed flame detectors, three of which are circled in one of the photos, are spotted at danger points around the engine, and an outbreak of fire near any one of them in-



Dashboard of bus equipped with fire detecting and extinguishing system. Right: Carbon dioxide goes to work

stantly flashes a warning red light at the dashboard. The operator's quick pull on a fire handle, either near his seat or on the exterior of bus, releases a flood of compressed carbon dioxide gas, which chokes out the fire. The gas is odorless and non-toxic, and causes no damage whatever to the engine.

The speed of the Kidde system's operation was demonstrated recently in special tests for the benefit of insurance officials, when gasoline fires which had been permitted to burn for 5 to 20 seconds, thoroughly heating surrounding metal parts, were detected in less than 1 second and extinguished in approximately 1.2 seconds, in spite of an artificially created wind velocity of 25 miles per hour.

PROTECTING PAINT

Is Protected in Turn by Aluminum

Asphalt, widely used as a roof-coating, has high resistance to rain and snow. But asphalt can't stand good weather. The sun plays havoc with asphalt. Hot summer rays cause it to bubble, melt, and run. Besides this, the sun's rays dry up the asphalt saturant contained in roof coatings.

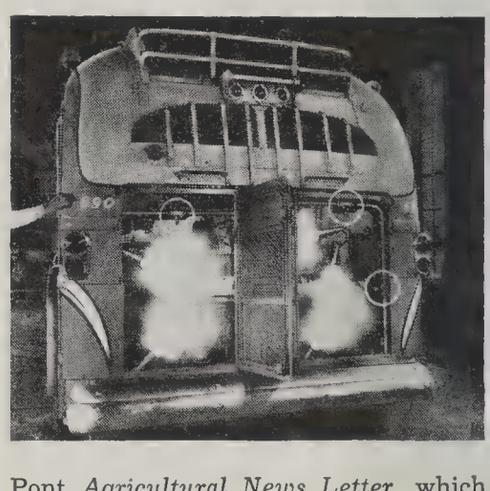
To overcome these draw-backs of an otherwise good roofing material, research men at the A. C. Horn laboratories combined asphalt roof coating with practically pure aluminum. Each particle of asphalt, so to speak, was provided with its own bright metallic reflector to throw back the destructive rays of the sun.

Both the asphalt coating and the integrally contained aluminum are brushed on to the roof at one time, from one can, in one operation for one purpose. Naturally and fortunately, some separation takes place when the law of specific gravity works. The asphalt sinks down to take up its bad-weather job of protection at the bottom of the coating, next to and bonded to the roof, whereas the aluminum stays at the top facing the sun and reflecting its rays.

SAVING FEATHERS

By Means of Chemical Preservative

Millions of pounds of wet-picked chicken and turkey feathers, formerly wasted or used only as fertilizer, can be saved for industrial processing by a simple and inexpensive preservative recently discovered by research scientists in the United States Department of Agriculture. Wet feathers, a by-product of poultry-dressing plants, normally decompose too rapidly to permit their shipment to feather-processing establishments, according to the Du

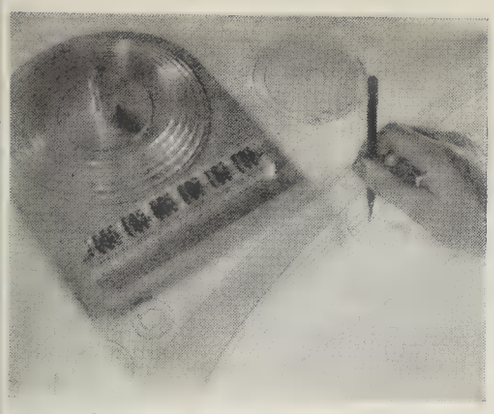


Pont *Agricultural News Letter*, which says the preservative is made by dissolving 15 pounds of common salt and 1 pint of commercial concentrated hydrochloric acid in 30 gallons of water, for each 15 pounds of wet feathers to be preserved. Practical tests included shipment of preserved feathers, while still wet, from Washington, D. C., to Denver and return. The feathers were in excellent condition after a month in shipment and subsequent storage, before being washed and processed.

PARALLEL LINES

Drawn On Curves Quickly With Simple Disks

An ingenious device for speedily drawing a line parallel to a splined line has been devised by Charles A. Jackson. The procedure consists simply of inserting the pencil point in a center hole



Smooth curves drawn rapidly

of a Plexiglas disk and then propelling the transparent plastic disk along the edge of the spline or French curve. A graduated set of disks takes care of ordinary requirements in splining. With the new instrument there is no lost motion and a line parallel to the splined line can be drawn quickly and accurately.

COOLANT

Increases Life of Diamond Wheels

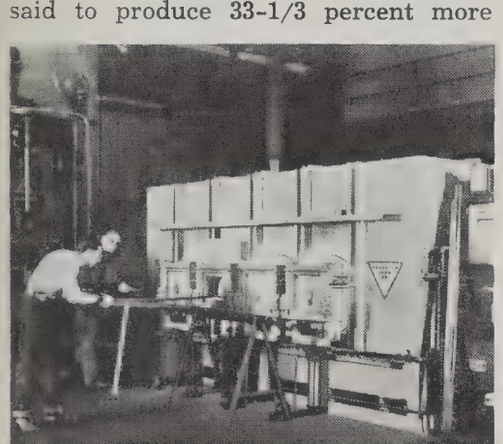
DIAMOND WHEEL coolant that clings tightly to the diamond surface and forms a film which prevents hot chips from imbedding themselves between the diamond teeth, so that wheels can clean without loading or glazing, permits such wheels to cut free and cool. The use of Super-Cut Coolant, compounded by Industrial Abrasives, Inc., is said to substantially improve finish, and, in addition, to add up to 25 percent more life to zurium bonded diamond wheels.

Super-Cut Coolant is reported to contain no harmful ingredients, and to be non-irritant, and non-toxic. It is sold in concentrate form which mixes with 20 parts of plain water, and can be applied by pump, wick, or drip feed in sufficient quantity to keep the diamond surface fully wet.

FORGING FURNACE

Uses Nitrogen Gas For Hard Steel Processing

USING only one half the floor space formerly required by three smaller furnaces, a new type Despatch controlled atmosphere forging furnace recently installed in an aircraft plant is said to produce 33-1/3 percent more heat than the total combined output of the three furnaces previously used. Compact and efficient, this new furnace utilizes a special four-in-row muffle arrangement to keep overall dimensions to less than 12 inches wide and 6 inches deep. Each muffle is 12 inches in diameter and has a working depth of 36 inches. Smooth uniform heat through the entire 36 inches working depth of muffles results from an ingenious system of back-towards-front firing.



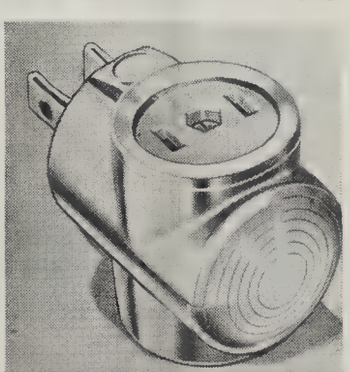
Compact new nitrogen gas furnace does work of three ordinary types

Processing hard steel forgings at 2250 degrees, Fahrenheit, this controlled atmosphere furnace uses nitrogen gas and handles over 2300 pieces per day. Air-operated doors shoot open quickly to allow fast removal of forgings from roomy, convenient-level hearths.

SAFETY PLUG

Has Built-In Light Bulb

ELECTRICALLY lighted, a new wall plug is a combination cord cap, convenience outlet and safety pilot, or nite-light. Encased in an attractive ivory plastics



Illuminated plug is easy to locate

housing, it plugs into any prong type wall electrical outlet.

A tiny bulb inside the housing of the new plug emits a soft glow through the front portion of the unit, providing a pilot light for conveniently locating wall receptacles, regardless of obscure location, without fumbling or hazard. In addition, it affords a night safety light for preventing fumbling and stumbling in darkened rooms, by establishing points around the walls that serve to orient a person. In nurseries, sickrooms, and many other locations, the subdued glow of the light is ample to serve as a night light.

Although the light burns continuously, day and night, as long as it is in the wall receptacle, tests show that it will operate at a cost of less than two cents per year for current. Since the bulb generates but little heat it has an extremely long service life and is reported to last for years without a burn-out.

Another feature of the new plug is that it provides two convenient outlets for plugging in other electrical fixtures. In addition, the LumiNite Safety Pilot Plug can be adapted as a cap for the end of the cord to an electrical device. In the rear portion of the housing is located a round thin section which can be easily knocked out by pushing a screw driver through it. The end of the

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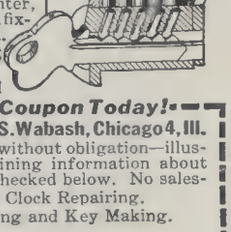


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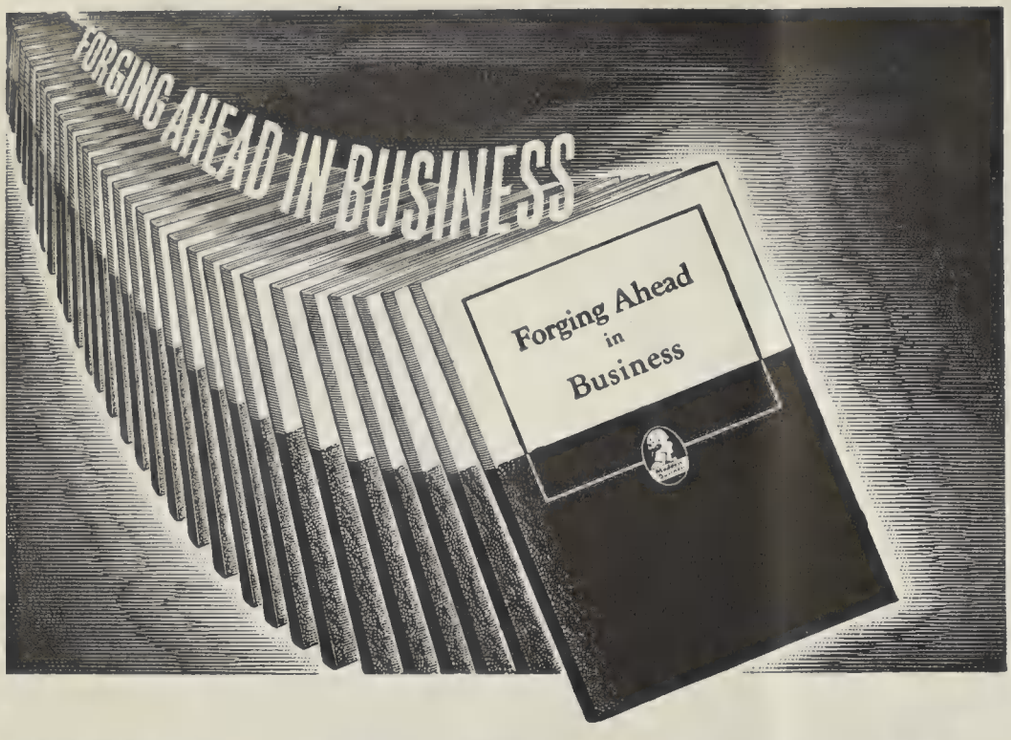


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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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electrical fixture cord can then be inserted through this round hole, knotted inside the plug, and easily connected to metal contacts by means of clinchers provided. Thus a single wall receptacle can accommodate three electrical fixtures in addition to serving as a pilot and safety light.

CHEMICALS HANDLING

Made Safer by Use of Fork Trucks

LARGE carboys of acids and cylindrical packages of chemicals in lump or powder form introduce industrial hazards when they are handled manually. In some plants these hazards have been eliminated and costs have been reduced by the use of electric fork-type lift trucks.

These Elwell-Parker units have enabled manufacturers to make the fullest use of the pallet system for rapid handling and, where necessary, for high tiering in warehouses. Four carboys in wood cases, with a total weight of



Truck handles chemicals safely

nearly a half ton, are easily handled in one load. To protect the necks of the carboys and afford a support for pallets above floor level, use is made of easily built wood frames. Dry chemicals in fiber, plastics, or wood containers weighing up to one ton or more also are handled by means of pallets and fork-type trucks.

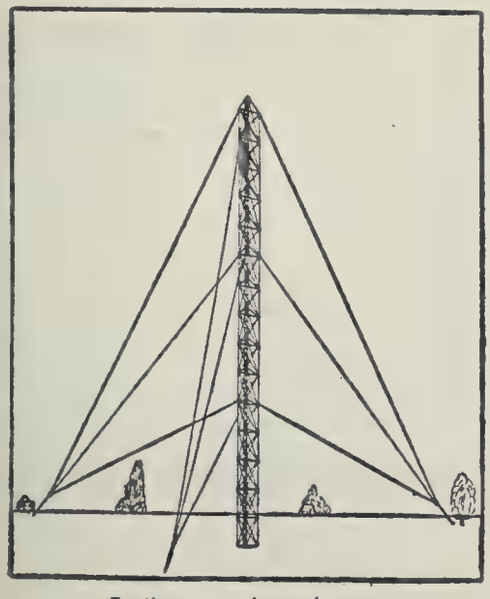
TRIANGULAR TOWER

Can be Erected Easily and Safely

CAPABLE of being erected by three unskilled men in ten hours because of simplicity of construction and small size and weight of individual members, a 90-foot Blizzard King tower offers many advantages for radio or construction use. Average weight of members is only 5.3 pounds; the heaviest is only eight pounds.

Each six foot section of the tower is used as a platform upon which to erect the next section. The members used consist of sleeve connections, tubular corner posts, horizontal steel

channel members, and diagonal flats. After any one section is completed and the ladder installed, the three corner posts of the next section are dropped into place. The sleeve connections are slipped over the top of the corner posts and the horizontal channels are bolted in place and followed by the



Easily erected steel tower

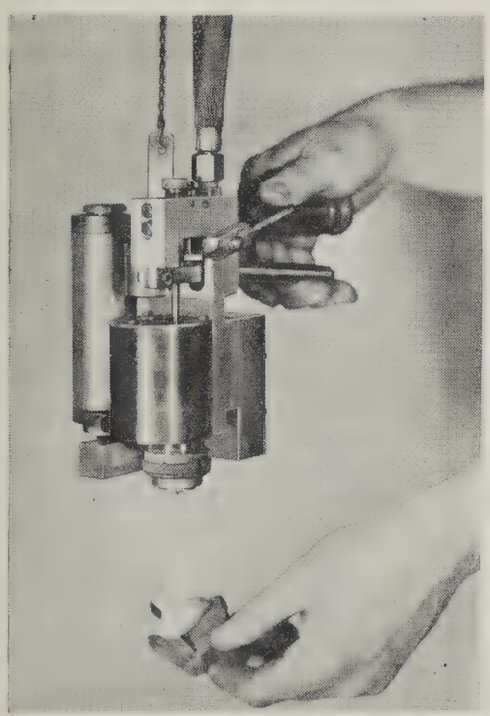
diagonals. The ladder is then installed and the operation repeated. The tower forms a complete safety basket around the ladder. These versatile towers are made by Harco Steel Construction Company.

ALLOY SPRAYER

Controls Flow of Molten Metal

BUILT especially for precision spraying of low temperature metals and alloys, a new sprayer, which is being used extensively for production spraying of selenium rectifier cells and rectifier disks, for protective coating of wood patterns, and similar spraying, is expected to be particularly useful in laboratory research work due to the closely controlled characteristics of the spray.

Although the new alloy-sprayer, des-



Precision controlled metal sprayer

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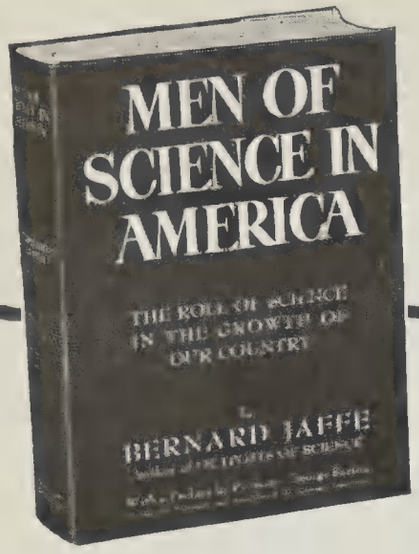
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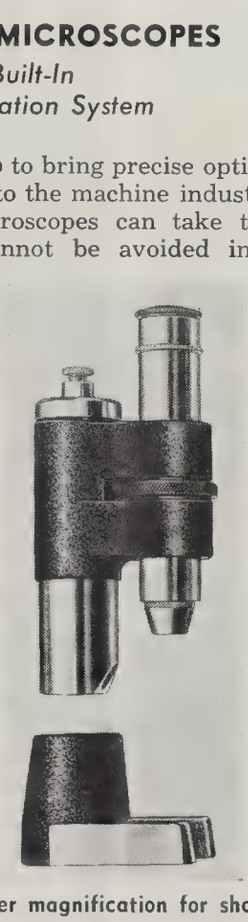
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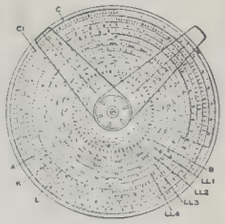
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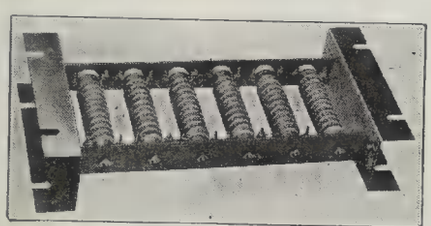
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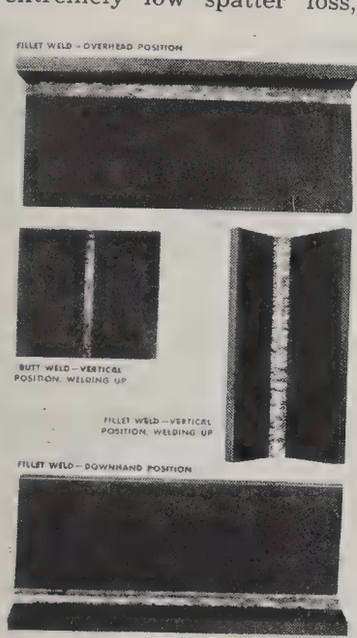
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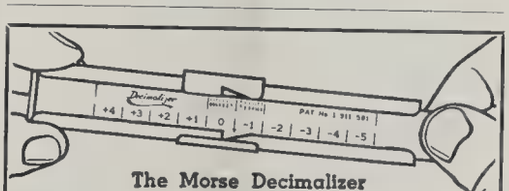
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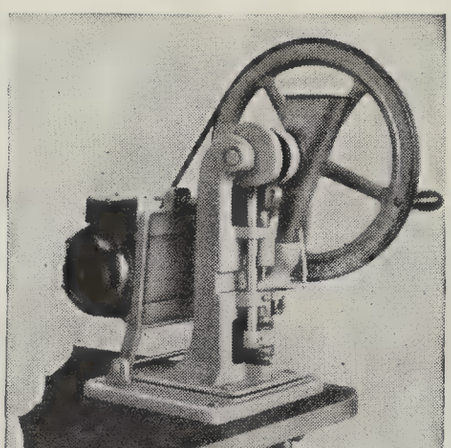
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Telescoptics

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Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

WHICH optical shop methods are best—professional or amateur? Neither. In each the needs are different. The professional makes many of a given thing, the amateur usually one. Such considerations as this call for adaptability of point of view. At least two professionals have related to your scribe with chuckles how they had employed amateurs and soon heard them saying, "The methods in this shop are wrong—'A.T.M.' says . . ." Thanks for sticking up for "A.T.M." but the mind should always be kept free and limber. Amateurs do single jobs.

One of the functions of this department is to dig stuff out of professional confines and offer it to amateurs. Few professionals these days find that this harms them. Most are more farsighted and are not like one of the old school near whom Porter worked in Washington during World War I. To a request of Porter's he replied, yes, he'd be willing to show some of his pet methods but "German spies, you know, are everywhere these days. Might overhear."

In the following two-part article, Patrick A. Driscoll, formerly of Rochester, now of Poplar Hill Road, Lima, N. Y., describes one method of making telescope mirrors, using a hand-lever spindle similar in principle to those shown in "A.T.M.," page 163, at *C*, and in "A.T.M.A.," page 151. Driscoll is an experimental lens maker in the Eastman Kodak Company Hawk-Eye Works and is the amateur who, in an article on making objective lenses, published in this department March last, described himself as "an amateur professional amateur"—he started as an amateur. His article:

THE barrel-head merry-go-round of grinding and polishing by hand, coupled with the amateur's almost universal use of the equal diameter grinder and mirror, leaves much to be desired. Grinding and polishing by hand often is laborious to the point of monotony; but, given the proper simple machinery and a fair amount of help, the basement optician can evolve a perfect optical surface and have fun in doing it, reducing grinding and polishing to a minimum. The following notes describe standard optical practice and can be relied upon to give good results.

Building the grinding and polishing machine shown in Figure 1 will call for an assortment of angle iron and so on, and a raid on the local junk yard. We shall also need a ¼-horsepower motor or, as a last desperate substitute resort, the family washing machine. The grinding machine will give excellent results both in working performance and the surfaces produced. It will handle a mirror up to 8″ in diameter, using V-belting on the spindle drive. The stroke will be from side to side, not back and forth, and will be manually applied with the lever shown. Spindle speed for grinding will be about 200 r.p.m., and for polishing about 36 r.p.m.

Long experimentation proves that, when grinding by hand on a machine, a concave surface should be ground face down, grinder on bottom, mirror on top. The grinder should be 5/4 the diameter of the mirror. A convex surface should be ground face up, with the grinder on top, and the grinder should be 4/5 the diameter of the other disk.

In polishing, the mirror should be on top, and the polisher should be 6/5 the diameter of the mirror, but with a convex surface the polisher should be on top and 5/6 the diameter of the other disk. For makers of reflectors or refractors these rules may be considered practical. Discussion of their philosophy would require too much space to prove what is accepted as correct by expert technicians because it works.

We shall assume that we are grinding a 6″ concave mirror and, in order to simplify division of diameters, all measurements will be given in millimeters, a smaller unit than inches. Since one inch is 25.4 mm, a 6″ blank is 152 mm in diameter. Therefore, by the rule just cited, a glass grinder of

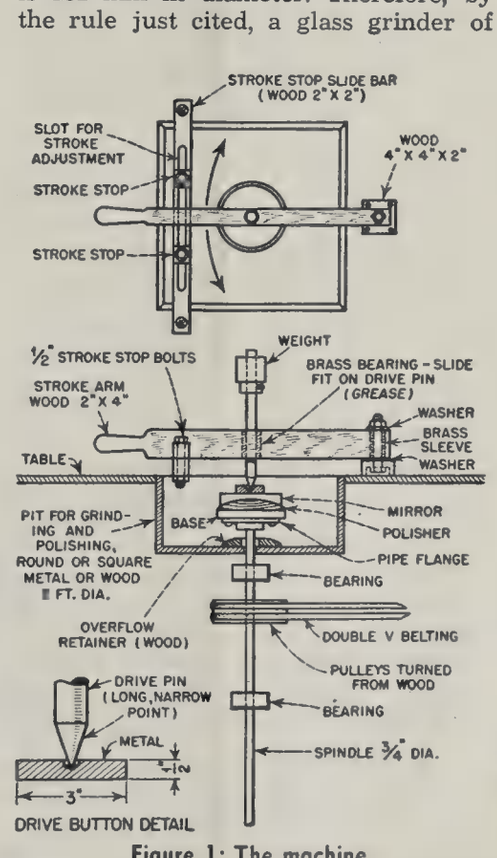


Figure 1: The machine

190 mm diameter is needed. For the mirror we purchase a rounded disk 24 x 152 mm.

The emeries will be numbers 180, 500, and 1200. On the machine these three sizes will give excellent results, and an elaborate sequence of grain sizes is unnecessary. If desired, 90 emery may be used to hog out the curve, but grinding to gage should be done in 180. Emeries 90, 180, and 500 may be had from The American Abrasive Co., Westfield, Massachusetts, and 1200 from the Bausch and Lomb Optical Co., Rochester, New York. (Carborundum also is good for roughing but as a finishing agent in precision work

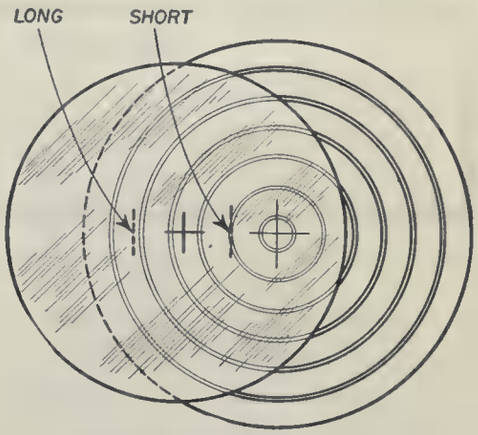


Figure 2: Stroke positions

it leaves something to be desired. The amateur's troubles with scratches is traceable more often to Carbo than to carelessness, since its granules are not so consistent in size as emeries.) Since it will be used in a pit (Figure 1) this permits recovery and re-use during the rough grinding stage (180) but the 500 and 1200 are too likely to become contaminated, and should not be recovered.

The mirror blank requires a driving button (Figure 1) which will be attached to the glass with pitch and remain there throughout the grinding and polishing operations. To fasten it to the blank we melt the pitch slowly, heat the blank and button, dip the button into the pitch and quickly place it on the blank, centering it before it becomes cold. In the same manner we pitch the tool on the spindle pipe flange shown in Figure 1, centering it by rotating the spindle and shifting it until the tool runs concentric.

Since the grinder and the mirror blank have flat surfaces it will be necessary to start the curve by hand grinding for about 15 minutes. We shall use a sweeping round-and-round stroke, keeping the center of the blank over the edge of the grinder. When the edge of the grinder shows a ground ring extending in about 1″ smaller than the mirror diameter we are ready to machine grind.

We replace the mirror on the grinder, engage the drive pin in the hole in the drive button and, with the mirror held offside on the grinder—say 2″ off center—start the spindle.

Emery is kept in a jar or can and fed on the grinder with a 1″ stiff-

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bristle brush. The emery should be well submerged in water, as the cutting effect of emery is at its best in a thin solution. A 1-quart jar half full of 180 emery is recommended, also that water be added until the emery is saturated and the jar full.

As the curve starts to form on the grinder and blank, both disks will rotate more smoothly, and so we commence swinging the stroke arm of the machine from side to side. From this point on, the stroke will determine the ground figure we wish to evolve.

Figure 2 shows stroke positions. These are calculated on a basis of the grinder diameter, as divided into four equal points. If the stroke overhang brings the center of the mirror to the respective indicated points on the grinder, as we move outward, we obtain the short, medium, and long stroke. With the mirror on top a stroke that is excessively long will shorten the radius. A short stroke will have a reverse effect. A long stroke will grind the center more than the edge, and a short stroke will grind the edge more than the center.

The drive arm should be swept slowly right and left. Tests for curvature should be frequent, and the stroke shortened or lengthened as these tests indicate.

A rule that must be remembered is: never use so long a stroke that the edge of the mirror crosses the center of the grinder, and never a stroke so short that it holds the mirror inside the diameter of the grinder.

On a short stroke the mirror must overhang the edge of the grinder, if only ¼", in order that the grinder will be used all over its surface at each stroke.

Emery is applied by a stroke of the brush at each stroke of the drive arm. It will be ejected by the grinder into the pit and in this rough-grinding stage it can be reclaimed and used again so long as the ejected portion still contains unused particles.

The grinder and mirror will rotate in the same direction. It is fallacious that the disks must rotate in opposite directions, as many even advanced workers insist. Direction of rotation has nothing to do with the production of a truly spherical surface, which is accomplished by the stroke and rotation of the spindle causing the grinder and work never exactly to duplicate the conditions of any one stroke.

As a check on the curvature I recommend the glass gage ("A.T.M.", page 344). Even for the worker who owns a spherometer the glass gage can be of value. The spherometer can, of course, be used to check the gage and mirror for sagitta, but the gage will also show the overall variation of the mirror along its arc when used as a check on radius and sphericity. The glass should be as thin as can be found and the gage must be very carefully executed. A slight variation in the scribing apparatus will have a bad effect on the arc that carries the glass cutter. Pivot bearing and scribing bar should be very rigid and the cutter must be held very tightly to assure a perfectly even cut on the glass. Make a gage about 14" long, if for a 6" mirror, and cut out the portion having the most even curve. Grind the edges lightly together in 500 emery. A minute's work will bring them to a tight fit.

The mirror, having been rough ground in 180 emery, must be brought to a tight fit on the gage before smoothing in 500 is undertaken.

We do not intend to grind by wets, as this method leaves the amount of glass removed in each size of emery to guesswork. By grinding exactly to

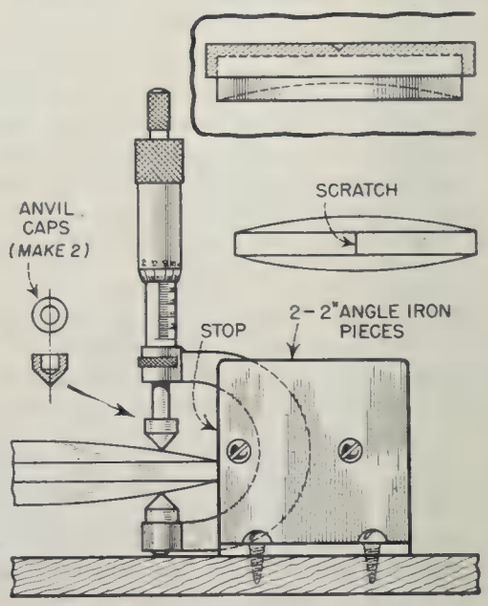


Figure 3: Micrometer in fixed stand. Insert: Chuck substitute for drive button on Figure 1

curvature in each emery, and miking the glass each time, we shall be very sure of eliminating the pits from each previous size. This should lay to rest, once and for all, the great disappointment of finding No. 180 pits holding over on the surface after it is polished.

The micrometer shown in Figure 3, with pointed tips over the anvils, will give accurate measurements of glass removal. The mirror must be marked on its edge with a permanent notch scratched in and filled with black paint, and this shall be the miking point.

After grinding with 180, the edge of the mirror is beveled. Hold a scrap of glass against the edge of the disk and, with the spindle running, apply a little 500 emery until the bevel is about 2 mm wide. This will eliminate future scratches due to edge particles breaking free. Retain this bevel throughout smooth (500) and fine (1200) grinding, and polishing. Keep the edge of the tool beveled also.

DRISCOLL'S article will be concluded next month. Observant readers will have discovered one important difference between the hand-lever spindles in "A.T.M." and "A.T.M.A." and Driscoll's. In the former the pressure on the work is regulated by the hand. In the latter the weight on the head of the free-floating pin regulates it uniformly.

The philosophy of dragging and dragged disks, which Driscoll found too lengthly to discuss here, is discussed at length in Dévé's "Optical Workshop Principles."

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3.



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4.



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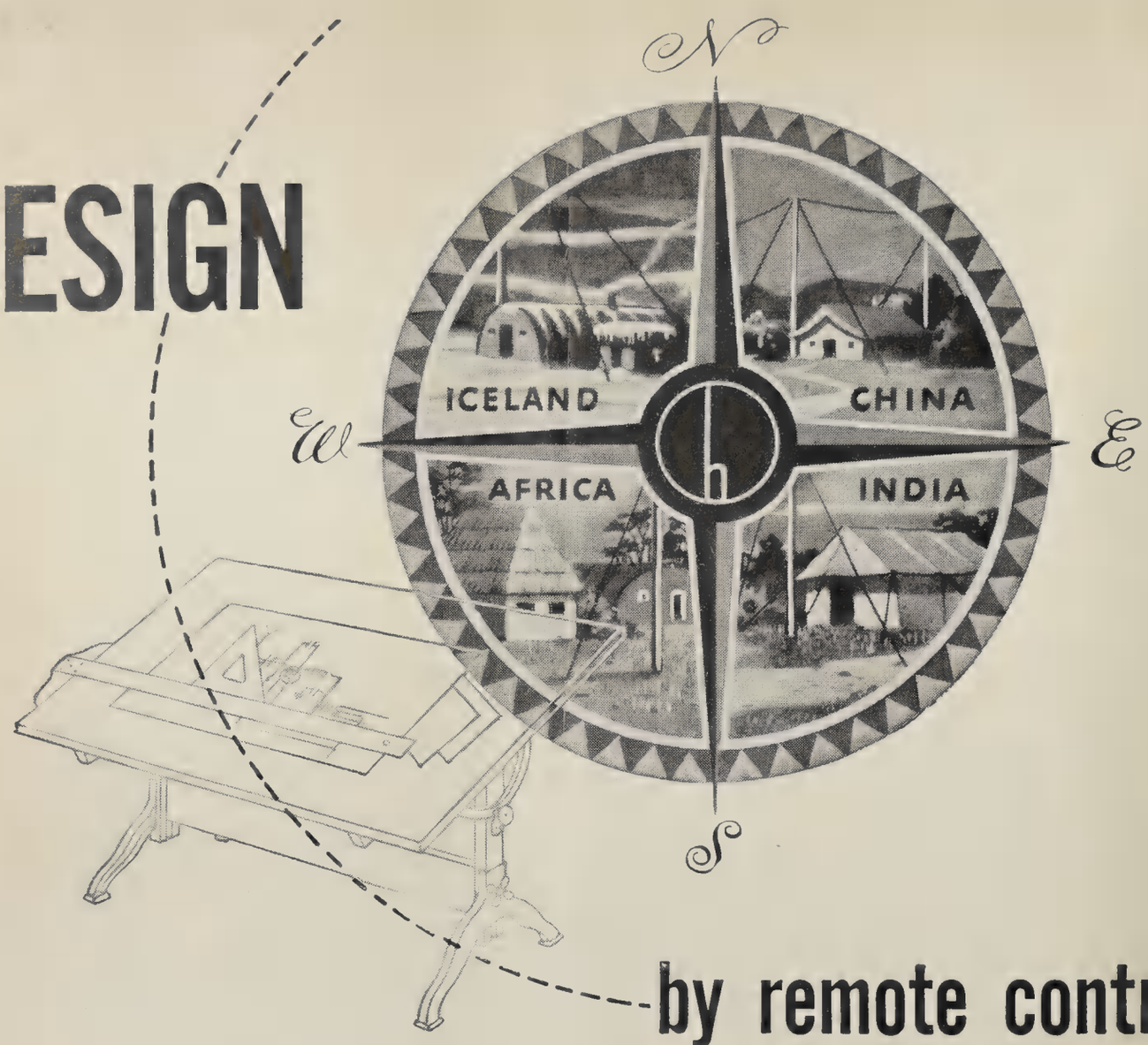


Storing Industry's Life-Blood . . . See page 257

The Story of THE PETROLEUM INDUSTRY

Anniversary Issue
No. 11

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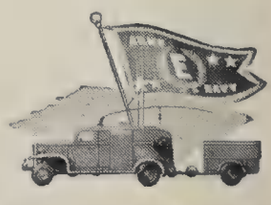


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Our Cover: Tank "farms" located near oil refineries are studded with metal storage tanks containing from 55,000 to 140,000 barrels each. In foreground of our cover is a pump and by-pass, the "heart" which controls the flow of oil to and from the tanks. Courtesy Standard Oil Company (New Jersey)

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Previews of the Industrial Horizon

By A. P. Peck

OIL RUSH

War's heavy drain on known underground petroleum reserves and the probability that civilian consumption of all types of petroleum products will increase in the near and more distant future, demand that something be done about it. And several things are being done that brighten the oil horizon considerably.

Up in the Pacific Northwest there is a new oil rush on. At the time of writing, no oil has yet been found in the area around Portland, Oregon, but a number of dry wells have been drilled and abandoned, others are down several thousand feet, and new drilling is being started almost every day. Cause of all the excitement in this area, where wild-catting has been going on sporadically for almost a quarter of a century, is two fold. Surface formations in this section of Oregon are identical with those in the highly productive fields of California, and geophysical prospecting has given definite indication that the underground formations are of the type in which oil may be found.

Still farther north, in the Canadian province of Alberta, oil exploration is going on apace. Twenty miles from Turner Valley, Canada's most productive oil field, geologists are confident that a dome-shaped formation has been located that will soon be producing crude; out on the Alberta plains a well was drilled last year that produced 1000 barrels a day and is now being held back to 100 barrels. Since then, other producing wells have been drilled, and still more are going down.

This is a brief view of part of the exploratory work that is going on in an effort to increase the proved oil reserves of the world. But there is another part of the picture that may someday become as important to the oil industry as the familiar drilled wells. This involves the extraction of petroleum from shale and sand. This type of work has been carried out on a small scale in many parts of the world but has the drawback that costs are too high. Now Socony-Vacuum has announced a new method of processing oil shale which, while still expensive, could make available 90 billion barrels of petroleum or in excess of four times the present probable proved crude oil reserves.

Now, back to Canada again, and to northern Alberta. Here, in and around Fort McMurray, is what has been reported as one of the world's largest oil reserves. The oil is at or near the surface, but it is mixed with sand; extracting the oil, again as in the case of shale, is expensive. However, four companies are actively at work in this region and have developed fairly economical methods of separating the oil from the sand. But then they are faced with the problems and expense of transportation. At present there is only a single-track railroad to the oil-sands area and freight rates are high. Someday a pipe-line to the "outside" may open up this rich resource.

Eventually the oil resources of this world are going to dwindle and disappear, but the work that the oil industry is doing today seems to be pushing that day farther into the future instead of bringing it closer.

MAGNESIUM POSSIBILITIES

Lighter than aluminum and, like that metal, available in almost unlimited quantities, magnesium may be considered as a war baby that has cut all its teeth and is now lustily chewing its way into many phases of industry. Thus far the surface has only been scratched, and the wheelbarrows and other gadgets that have been featured in the daily press are mere straws in the wind. Wherever lightness and rigidity are required, there magnesium holds promise. Production problems have been solved; the metal can be adequately protected from corrosion; methods of welding have been perfected; casting procedures no longer present difficulties—all in all, magnesium is not only ready to go, but it is going places rapidly.

In the textile industry magnesium is replacing steel and wood for such parts of machinery as have to be handled in the mill or sent by freight; thus labor and transportation costs are reduced. Used in fabricating movable roller conveyors, magnesium makes the unit so light that one man can move it from place to place instead of calling for additional help or using a plant truck. These are only two concrete examples; the future will disclose many more possibilities as thinking machine designers delve into available facts about magnesium and really put the metal to work.

PUDDING PROOF

No one department of an airline can anticipate all the various problems which may arise in connection with the operation of an airplane. With this truism in mind, American Airlines has invited nearly all of its 10,000 employees to aid in the selection of a new utility type of plane. The plane to be used will be selected from several specifications after the employee survey is completed.

Here is an approach to an industrial problem that parallels familiar consumer polls. It could well be extended to machine tools, plant layout, materials handling, and even materials selection.

SMOKELESS CITIES

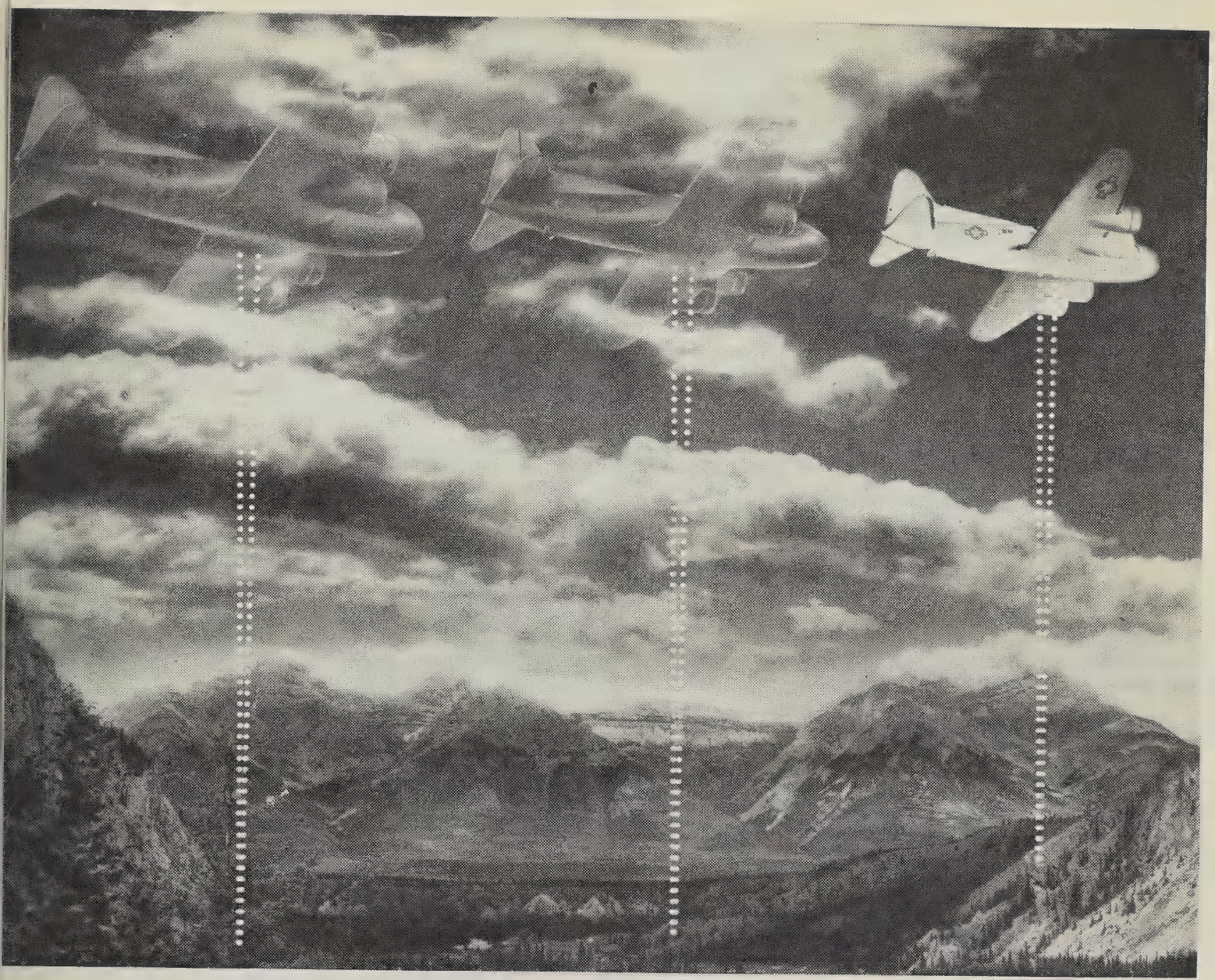
Just before the war, St. Louis succeeded, by passing laws that were drastically enforced, in virtually eliminating industrial and residential smoke from its atmosphere. Other cities were ready to follow suit when the war emergency pushed the problem into the background. Now the question of city smoke comes up again.

In the meantime, smoke precipitators have been improved, smokeless stoves burning bituminous coal have been developed, and furnace attachments have been perfected which eliminate smoke. Another approach to the problem is group heating of buildings, where highly efficient fuel-burning equipment is in charge of an experienced fireman.

City smoke is wasteful, not only from the fuel standpoint but because it increases laundry and painting bills and probably has serious health implications. It can, and should, be eliminated.

FOR FUTURE REFERENCE

By using aluminum as a coating for steel and as a deoxidizing agent in the manufacture of steel, it is foreseen that the steel industry will become one of the principle customers of the aluminum industry. . . The Department of Agriculture estimates that farmers in the United States may buy 200,000 tractors a year for the next three years. . . Despite cancellations, machine-tool manufacturers report huge backlogs of orders, especially in high-production machines; apparently few industries are willing to wait for release of government owned equipment, both because of the time element and the risk of obtaining tools that are on their last legs. . . In a recent housing survey, only 3 percent of the people questioned said that they were considering purchase of prefabricated houses . . . Fallen trees, left in the woods from one logging season to the next, may be saved from insect destruction by DDT.



The RCA Radio Altimeter assures that the last mountains have been passed before letting down to the airport in the valley below.

Measuring "every bump on the landscape" —at 20,000 Feet!

A radio altimeter—that indicates the exact height above land or sea—is another RCA contribution to aviation.

Old-style altimeters gave only the approximate height above sea level—did not warn of unexpected "off-course" mountains.

To perfect a better altimeter was one of science's most baffling problems. So RCA developed an instrument so accurate it "measures every bump on the landscape" from the highest possible altitudes...so sensitive it can measure the height of a house at 500 feet!

This altimeter—actually a form of radar—directs radio waves from the airplane to earth and back again . . . tells the pilot exactly how far he is from the ground...warns of dangerously close clearance . . ."sees" through heaviest fog or snow.

All the radio altimeters used in Army, Navy and British aircraft were designed and first produced by RCA. This same pioneering research goes into *every* RCA product. So when you buy an RCA Victor radio, Victrola, television receiver, even a radio tube replacement, you enjoy a unique pride of ownership. For you know it is one of the finest instruments of its kind that science has yet achieved.

Radio Corporation of America, Radio City, New York 20. *Listen to The RCA Show, Sunday, 4:30 P. M., E. T., over NBC.*



The RCA radio altimeter will be a major contribution to the safety of post-war commercial flying. The section at the left sends the radio waves to earth and back again while the "box" at the right—timing these waves to the millionth of a second—tells the navigator the plane's exact height in feet.

RCA **RADIO CORPORATION of AMERICA**

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of November, 1895)

CARBORUNDUM—"Among the new industries resulting from the economical production of electrical current at Niagara Falls is that of Carborundum. . . To produce Carborundum at the lowest possible cost, and thereby permit of its general adoption as an abrasive for all classes of work, has of course been a subject of vast importance to the Carborundum Company, and after having investigated the possibilities of Niagara Falls as a manufacturing point, they determined to locate a plant in that city that they might have the benefits of cheap power from the Power Company and have also the advantage of railway facilities there offered."

PUNKAH PULLERS — "There are over 120 patents for punkah pullers, and yet none have come into general use in India. . . . So long as the coolie is cheaper than the cost of working a machine puller, there is no chance of their ever coming into general uses."

ELECTRIC LOCOMOTIVES — "The first of the lot of four electric locomotives to be built by the General Electric Company for the Baltimore & Ohio tunnel at Baltimore is in active service. The second one is being shipped in parts. The contract requires the engine to haul 15 loaded passenger cars and a locomotive at 35 miles an hour and 30 loaded freight cars and locomotive at 15 miles an hour through the tunnel up an 0.8 percent grade."

NATURAL GAS — "Since 1886 natural gas has been a commercial product in Kansas, where it has been found in numerous localities, although the total supply thus far ob-



tained has not been great. Quite recently, however, oil and gas were discovered in the southeastern part of the State, and several companies obtained leases and began prospecting, the Palmer Oil and Gas Company, of Ohio, operating in the neighborhood of Iola, Kansas. In a well recently drilled near that place, the pressure of the flow of gas was so great that drilling operations had to be suspended, and, after getting the well under control, the managers arranged to drill a second well by operating the engine and drilling plant with the high pressure gas obtained from the first well."

TRANSSIBERIAN — "A work of prime importance is now being accomplished in Asia, silently and without parade—the construction of the Transsiberian Railway. When finished, this line will exceed in length any of those that exist upon the globe. In fact, its length, from Tcheliabinsk, its initial point, to Vladivostok, its terminus, will be 4,536 miles, while the length of the Transcanadian, which is alone worthy of being compared with it, reaches, between Montreal and Vancouver, but 2,760 miles."

FIREPROOF — "The ideal fireproof building should fulfill three conditions: 1. It should be proof against attack from without. 2. The skeleton frame, consisting of steel columns and horizontal girders, should be inclosed in some thoroughly fireproof material. 3. It should be able to localize a fire, and confine it to the particular floor upon which it originates."

RATIONS — "The federal government has been experimenting at its various military posts with condensed army rations. . . . The theory of condensed rations is, not that they shall serve the army as permanent food, but rather as provision to be taken along in an emergency. The condensed rations have less weight and bulk than the regular rations, but the prime desideratum was that the food should be serviceable in emergency cases, for expeditions of about four days' duration."

INDIAN SILK — "Though the Indian trade in silk has fallen off since the days when the Portuguese found the silk-laden ships of the merchants of Cambay the greatest prize they could win, or the industry constituted the chief source of revenue to the old 'Honorable Company,' yet still it forms in the raw a very appreciable item in the commerce of India."

GLASS HOUSES — "The day may yet arrive when people will live in glass houses. A patent has been secured for glass bricks of a peculiar pattern. The material of which they are composed being a first rate non-conductor, these bricks will keep the cold out of a dwelling built of them, while admitting the light. It is claimed they will exclude noise, being hollow. Furthermore, the inmates of a glass house need not be afraid of being under too close observation by neighbors, inasmuch that it is not requisite that the bricks shall be transparent. They may be of opaque ground glass or of any color that may be suitable for decorative effect."

SAFETY — "A safety appliance for electric wires consists of a bracket at the top of the pole which supports the line, the bracket having at its extremity a pear-shaped loop, the inner portion of which has a sharp edge. . . When the line breaks it drops upon the sharp edge of the loop, which cuts the insulation, if there be any, and forms an electric contact with the bracket, and the bracket being connected by a wire with the ground, the fallen wire is immediately grounded and the portion lying outside of the loop or within reach is thus rendered harmless."

WATERWHEEL — "A waterwheel of remarkable construction has been introduced in the North Star mine, Grass Valley, Cal. It is eighteen feet in diameter, weighs 10,500 pounds and develops 250 horse power, running under 750 feet head, at 110 revolutions, and is directly connected to the shaft of a duplex compressor, compound tandem type, of same capacity. . . From a cast-iron hub radiate twenty-four steel spokes, which are connected to a rim made up of angle iron properly shaped, having a slat for the buckets, which are bolted to the periphery, the strain being taken by four heavy steel truss rods."

LIQUID AIR — "An interesting illustration of the rapidity with which purely scientific discoveries frequently become the starting point of new industries is furnished by the case of liquid air. It is no long time since liquid air was produced for the first time in quantities great enough to admit of its application for purposes of research; yet steps are already being taken to treat liquid air as an article of commerce and to turn it out upon a large scale."

WOOD "CANS" — "Wood pulp fruit cans are among the latest applications of wood fiber to a useful purpose. One method of manufacture consists in taking the soft pulp direct from the wire netting and moulding it into cylindrical form, about the length of a dozen cans, and keeping it as hollow tubes until ready for cutting and heading."

• • •



TINY GIANT WITH A HISTORY

Long before the war, the men who design your Bell Telephone System were looking for an electron tube with frequency capabilities never before attained. With it, they could transmit wide bands of telephone messages — several hundred of them — simultaneously through coaxial cable—economically, and over long distances.

They developed a tube which set a new standard in broad-band, high-frequency amplification. So minute that its electrode system had to be inspected under a magnifying glass, the tube could amplify either the voices of 480 people talking at the same time, or the patterns of television. Long-distance, broad-band transmission became a commercial reality.

6AK5



Cross-section of Electrode System (five times actual size)

When war came, this tube excelled all others as an amplifier in certain military equipment. It then grew into the 6AK5, one of the great little tubes of the war. Besides producing 6AK5's in large quantities, the Western Electric responded to emergency needs of the Army and Navy by furnishing design specifications and production techniques to other manufacturers, of whom at least five reached quantity production. On every battlefront it helped our ships and planes to bring in radio signals.

Developing electron tubes of revolutionary design has been the steady job of Bell Laboratories scientists ever since they devised the first practical telephone amplifier over thirty years ago. Now tubes like the 6AK5 will help speed the living pictures of television, as well as hundreds of telephone conversations simultaneously over the coaxial and radio highways of the Bell Telephone System.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for continued improvements and economies in telephone service.

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You can utilize today's gasoline quality to pay extra dividends in power and economy

BETTER GASOLINE is no longer a hope — it's a reality. Gasoline companies are now supplying gasoline with improved base stock and higher octane ratings.

This high-quality fuel will be of great value to truck operators, who are faced with the changing conditions of the postwar world—heavier competition in the truck field, demand for better service, and the need for lower ton-mile operating costs. *Higher octane gasoline, used to full advantage, can help provide the extra power, performance and economy needed to solve these problems.*

In ordering new equipment, you'll want to specify compression ratios to utilize better gasoline. Many engines now in service can also be brought up to date—can be modified to utilize improved antiknock value.

By keeping pace with gasoline improvements you will be taking a long step toward more economical operation per ton mile.

More power from every gallon of gasoline and from every cubic inch of engine displacement through

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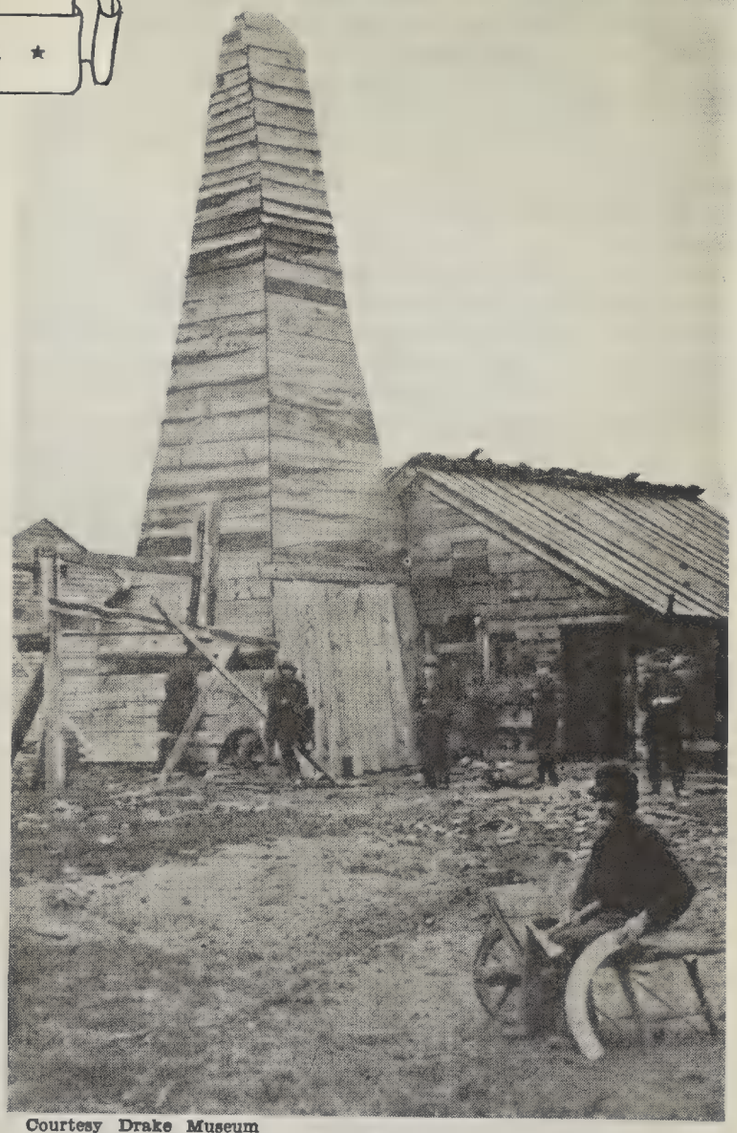
Scientific American
NOVEMBER · 1945

* 100th Anniversary Year *

Life-Blood Of The World

Petroleum Was Known and Used in Limited Ways for Thousands of Years Before It Was First Deliberately Sought After on a Commercial Scale. Then Came "Drake's Folly" and the Dawn of the Petroleum Age. The Development of Production, Transportation, and Processing of Crude Oil Presents a Vivid Background Against Which to Evaluate Achievements of the Petroleum Industry

By RUSSELL HOGIN
American Petroleum Institute



Courtesy Drake Museum

The famous Drake oil well rig as it appeared about 1864. In the foreground, sitting on wheelbarrow, is "Uncle Billy" Smith, who did the actual drilling

REAL beginnings of the petroleum industry of the world date back only to the middle of the 19th Century, when Drake drilled the first well ever sunk in deliberate search of a supply of "black gold." Yet, as long as history has been recorded, and even before, mankind has been making use of petroleum in one or another of the many natural forms in which it is found. The chariots of ancient Egypt's pharoahs were greased with a lubricant provided by nature and the bodies of these mighty monarchs were preserved in pitch obtained from the same sources. Herodotus relates that the walls of Babylon were cemented by a mortar of pitch; the curious round boats that have plied the waters of the Euphrates from the time of Nebuchadnezzar to the present day are made water-tight with pitch; the Bible states that Noah's Ark was made of gopher wood, pitched "within and without with pitch."

The Zoroastrians of ancient Persia built their temples around natural gas vents in what is now the Baku oil field and thus obtained the "eternal fire" which they worshipped. The more practical Chinese were using natural gas carried through bamboo pipelines to heat and light their houses 2000 years ago, and Pliny tells us that oil from Sicily was burned in the temple of Jupiter. There are many other references to the use of petroleum in ancient times and there is, in addition, a large body of evidence of its use not set down in written history.

One of the strangest of the latter is that oil pits were dug in eastern North America at least hundreds of years before the first white man set foot on this continent. These ancient workings in the oil regions of Pennsylvania, Kentucky, and Ohio have been examined carefully by a number of early historians who fairly well agree that these pits are hundreds of years old and that they were used to collect oil. These workings had long since been abandoned when they were first noticed by early-day explorers. Large trees were growing out of some of them, testifying to their age.

Nobody knows who the ancient people were who dug these pits, nor the use to which they put the oil. The pits do not resemble the work of Indians, who were not given to the digging of wells. These ancient oil pits were carefully prepared, frequently lined with timbers that had been hewn with stone axes, and in some cases were dug to a considerable depth. The evidence is strong that the eastern petroleum fields were producing oil hundreds of years ago and on a more extensive scale than they were when the white man first penetrated these regions.

The first Europeans to visit the New World found the Indians collecting and using petroleum. Spanish explorers visiting Peru in 1527 named La Brea after the asphalt deposits there. Juan Rodriguez Cabrillo, a Portuguese navigator in the employ of the Spanish, toured the coast of California in 1542-3 and found the Indians at what is now Carpenteria, California, waterproofing their dugout canoes from a pitch deposit there. Cabrillo took advantage of the deposit to repair his

ships, as did many navigators in those distant days of uncharted seas and fragile wooden ships. At approximately the same time a group of the survivors of the De Soto expedition, attempting to make their way from the mouth of the Mississippi back to Mexico, were blown ashore near Sabine Pass, Texas, and repaired their boats at a nearby pitch deposit.

The first written reference to the use of petroleum on this continent in its more familiar liquid form was made in 1627 by a French missionary, Joseph de la Roche D'Allion. This lay brother followed the Indian trails to a famous oil spring near what is now Cuba, New York, which was under the control of a branch of the Iroquois tribe whom the French called the "Neutral" Indians. Warfare was forbidden in the area around the spring over which these Indians held sway, and access to the oil was open to all.

De la Roche recorded his experiences in a letter dated July 18, 1627, in which he said that "these Indians collect a good kind of oil called Antonotons, which is translated to mean 'oh how much there is of it.'" Other French missionaries later visited the spring, and by 1670 it was marked on a map of the French colonies.

For two centuries thereafter, the story of petroleum follows an unvarying pattern. As the early traders and explorers followed the Indian trails across the Alleghenies, the Great Smokies, and up into Texas from Mexico, they found the Indians collecting seepage oil and using it as a medicine for themselves and as a cure for ailments of horses. The early travelers and settlers followed their example.

The Indians had an unusual custom of "peace trails" and "war trails." Situated on the peace trails were common necessities such as salt deposits, oil springs, and the like. A party of Indians traveling the peace trail could traverse hostile areas to obtain these necessities without danger of attack. The early white men noted this and acted accordingly. The trail down Oil Creek in Venango County, Pennsylvania, was one of these peace trails. Petroleum flowed as scum over the surface of this creek, which later was the scene of the first oil well and the first oil boom. The seepage area in Nacogdoches County, Texas, was known to travelers



"Kicking down" a well in the early days of the oil industry was only a slight improvement on the method used in China for many centuries to sink water wells

up the Spanish Trail as early as 1790. They collected the oil to use as a lubricant for the axles of their wagons and carts, in addition to the common use as a supposed cure-all for man and beast.

William Byrd III noted two oil springs southwest of Richmond, Virginia, in 1705, although their exact location is now unknown and in 1753 George Washington and General Andrew Lewis received a patent on a section of land near Charleston, West Virginia, that contained a "burning spring." All of these and doubtless many other oil seeps were known and visited by the early settlers.

DESPISED PETROLEUM — The world's first oil well was drilled in 1859, but the method by which it was drilled was developed west of the Alleghenies in 1806. Salt was a highly prized commodity in the newly settled western country and the Ruffner brothers started a salt works in 1806 at what is now Charleston, West Virginia. Their procedure was to drill a well to salt water, which then would flow to the surface in artesian fashion; the salt was obtained from the brine by evaporation.

The Ruffners' method was to dig a shaft down to

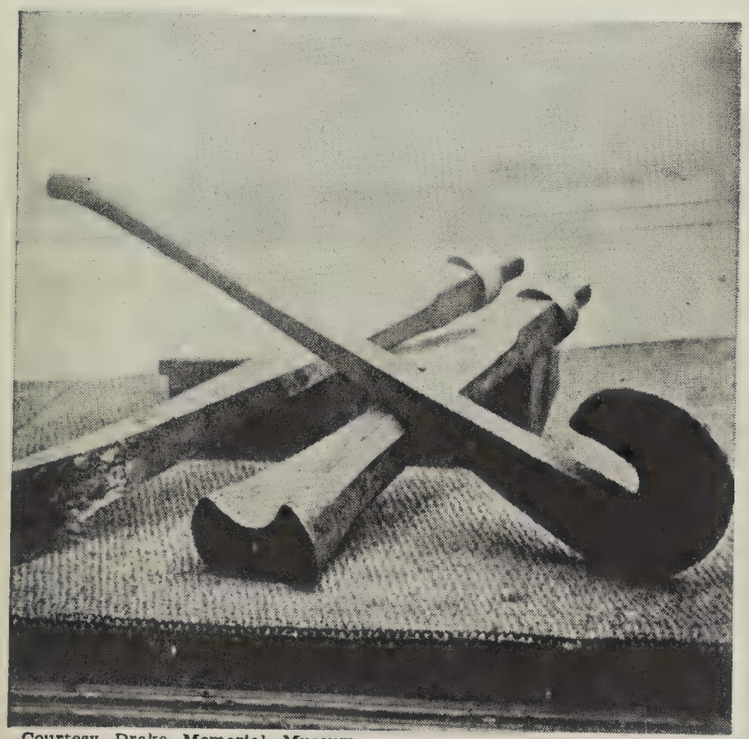


From Scientific American

Oil well in Ohio, drilled in 1864, which has continued to produce for over three quarters of a century

bedrock and to fix a "conductor" made of a hollow sycamore log in the shaft. They then drilled through the log down to a depth of 58 feet, where they struck a strong flow of salt water. The Ruffners encountered only a small amount of oil in their well, but did get a flow of natural gas which they used for fuel for evaporating the water from the salt. Many of the later salt-well drillers were not so lucky. They got large quantities of petroleum, for which they had no use whatsoever.

It is of interest to note the Ruffners' drilling method, not only because it was widely used in the early oil fields, but because the Chinese had invented it 2000 years before. The chief feature of the method was the spring pole, a green tree trunk some 40 feet in length with one end firmly imbedded in the ground or attached to the butt of a tree. The pole passed over a forked post, with the lighter, or spring, end of the pole extending over the drilling site. The drilling tools were attached



Courtesy Drake Memorial Museum

Tools used in drilling the Drake oil well in 1859

to the spring pole. These consisted mainly of a heavy length of iron, slightly sharpened on the end, and chained to the spring pole. A couple of men would throw their weight on the spring end of the pole, thus dashing the iron bit against the bottom of the hole. There were a number of variations of this primitive method in later wells, but the spring-pole rig remained in use for a long time.

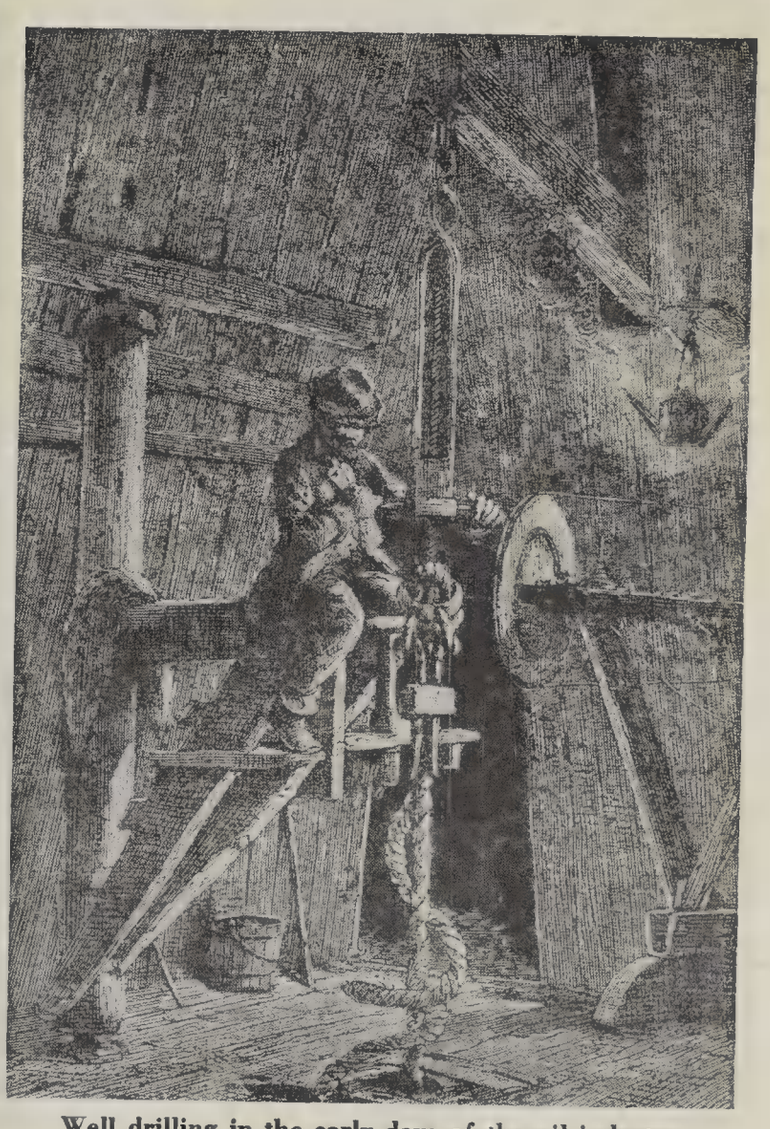
For almost half a century after the Ruffners drilled their first well, petroleum was a despised and thrice-cursed intruder to the salt-well drillers of the Ohio Valley region. Nobody wanted it. The small amount used as medicine and as a lubricant was readily obtainable otherwise and the remainder was not only a drug on the market, but a discouraging deterrent to the profitable business of obtaining salt. Oil ran out onto the ground from salt wells, floated down rivers and streams, caught fire, and served mankind only as a topic of conversation in the pioneer countryside.

True, as early as 1819, men were suggesting simple refining methods to remove the unpleasant odor from burning crude oil, thus making it available as an illuminant, but nothing was done about it at the time. The best explanation for this apparent lack of foresight seems to be that the world simply was not yet ready for oil and men's imaginations had not envisioned its possibilities. We do know that when oil was found in quantity in 1829 in Cumberland County, Kentucky, as a result of the usual salt-well curse, it was allowed to flow for months down the Cumberland River, reaching as far as Gallatin, Tennessee, 100 miles away. The oil later caught fire, and the "burning Cumberland" was noted and commented upon all over the burgeoning United States.

The times cried for a new source of light. In common use were tallow candles, sperm oil lamps, pine knot torches, and open fires—essentially unchanged since the dawn of history. The world wanted something better and in various countries men were seeking it. James Young of Scotland distilled "paraffine oil" from shale and coal in 1848; Abraham Gessner, a Canadian, started the manufacture of illuminating oil from coal at about the same time. Gessner called his product "kerosine," but "coal oil" was the popular name for it for years to come. Tiny refineries sprang up throughout the United States and a brisk industry was aborning when Colonel Edwin L. Drake drilled the world's first oil well on the banks of Oil Creek, near Titusville, Pennsylvania, on August 27, 1859, and the Petroleum Age began.

DEVELOPMENT STARTS — Many men had a part in that first oil well. It was the result of a chain of actions. The time was ripe for beginning the development of this great natural resource and men and events moved in sequence to bring it about.

George H. Bissell, New York lawyer and New Haven businessman, started it. The story goes that, in 1854, he visited Dartmouth College, his alma mater, and called upon Professor Crosby of the chemistry department. The professor showed Bissell a small bottle of crude



Well drilling in the early days of the oil industry



Photo taken in 1865. Courtesy The Texas Company

Within a few years after the Drake well was brought in, oil derricks dotted the Pennsylvania and Ohio country sides

oil sent by his nephew, Francis B. Brewer, who had collected it from an oil spring on his father's land near Titusville, Pennsylvania.

Bissell was impressed. Here was Opportunity with a capital O and he determined to take advantage of it. Persuading his former law partner, Jonathan G. Eveleth, to join him, Bissell leased, in November of 1854, 105 acres of land from Brewer for 99 years without royalty. The price was $5000; $500 down and the rest on notes from Bissell.

The opening move of this first oil operation was to have the land trenched to collect the surface seepage oil. When three barrels had been collected, they were sent to Benjamin Silliman, Jr., professor of chemistry at Yale University.

The report of this chemist is a monument to scientific analysis. He analyzed the many components of the crude oil and set the pattern for refining that has endured to this day. He concluded with the statement that many valuable products could be obtained from petroleum. That did it. While it took Bissell five years to get an oil well—and many more years for refining to emerge from its swaddling clothes—nevertheless the basic facts about this great mineral resource were resolved.



Courtesy American Petroleum Institute

One of the early Pennsylvania oil refineries

ORGANIZING FOR OIL — Backed by the Silliman report, Bissell and Eveleth obtained limited backing from a banker, James M. Townsend, and others and that same year, 1854, the Pennsylvania Rock Oil Company was formed. The company later was reorganized as the Seneca Oil Company and it was this latter concern that drilled the Drake well.

There was Bissell, then, with oil land, with capital, and with a report that indicated a profitable use for the product. The problem was how to get it out of the ground in commercial quantities. Samuel M. Kier, a salt-well owner of Pittsburgh, provided the answer.

Kier, associated with his father, had put down two 400-foot salt wells on the Allegheny River near Pittsburgh. True to form, they produced some oil. The resourceful Kier, having no ready market for his oil, put it through a crude refining process, and put it up in half-pint bottles labeled "Kier's Petroleum or Rock Oil, Celebrated for its Wonderful Curative Powers. A Natural Remedy. Produced from a Well in Allegheny County, Pennsylvania, 400 Feet Below the Earth's Surface." Alongside the lettering were drawings of the derricks used in boring and pumping the brine wells.

Bissell saw one of these bottles in a New York drug store window in 1857 and decided immediately to drill for oil in the same manner in which salt wells were drilled. Colonel Edwin L. Drake, a 40-year-old railroad conductor, was hired by the company to go to Titusville and arrange to drill a well.

Colonel Drake, whose title was purely complimentary although it stuck to him for life, reached Titusville in May, 1858, and proceeded to encounter every kind of trouble possible to a new venture. He was beset by lack of finances, lack of faith, and lack of knowledge. His as-

sociates failed to meet their financial commitments and Drake was forced to strain his own limited credit to the utmost. The countryside, almost to a man, scoffed at the idea of drilling for oil. "Drake's Folly" became a topic of conversation as far away as Pittsburgh.

Drake was a patient, steadfast man, however. He visited the salt wells at Tarentum and studied drilling methods and talked to salt-well drillers. Finally, he found the experienced driller he needed for his experiment. That man was "Uncle Billy" Smith, who was assisted by his two sons. The well was rigged up in June, 1859, close by the oil spring from which Drake had been collecting seepage oil.

Then Drake made his big contribution to oil drilling. He had an iron pipe driven from the surface down 39 feet to solid rock. The drill stem was inserted in the pipe and the world's first oil well was on its way. On a sultry Saturday afternoon, August 27, 1859, Uncle Billy found oil bubbling in the pipe within a few feet of the surface. Bottom of the hole was at 69½ feet.

Uncle Billy jumped on a mule and hurried to Titusville to spread the good word. That oil brought $20 a barrel. Less than three years later, oil was down to 10 cents a barrel, so rapidly had the Oil Creek region between Titusville and Oil City been drilled after Colonel Drake pioneered the way.

For a good half dozen years or more, the Oil Creek area was a milling maelstrom of brawling rivermen and teamsters among closely packed oil wells. Vice flourished openly. Conflagrations were of almost daily occurrence. Mud—deep mud—was everywhere. It was a wild and roaring time as a great industry went through its birth pains.

Refineries sprang up at Oil City, Pittsburgh, Philadelphia, Cleveland, and New York. (The first one was built at Titusville in 1860 by William Barnsdall and William H. Abbott.) These small "teakettle" refineries had one principal product, kerosine. Gasoline, produced naturally and as a by-product of kerosine refining, was known as "volatile spirits" or naphtha and was the curse of the industry. It was a dangerous nuisance that sometimes contaminated kerosine, causing lamps and lanterns to explode. Hence the gasoline at refineries was shot into the air as gas, dumped into lakes and streams, burned—or gotten rid of by whatever other expedient the exasperated refiner could find.



Courtesy Drake Memorial Museum

In the 1860s, before the advent of pipe lines, oil was transported in drums by slow horse-drawn wagons

OIL TRANSPORTATION — Earliest method of transporting crude oil from wells to refineries was in barrels carried on lumbering horse-drawn wagons. Dirt roads and mud limited severely the quantity of oil that could be carried and the speed with which it could be moved. However, from the middle 60's on, the industry made good progress in solving the important problem of trans-



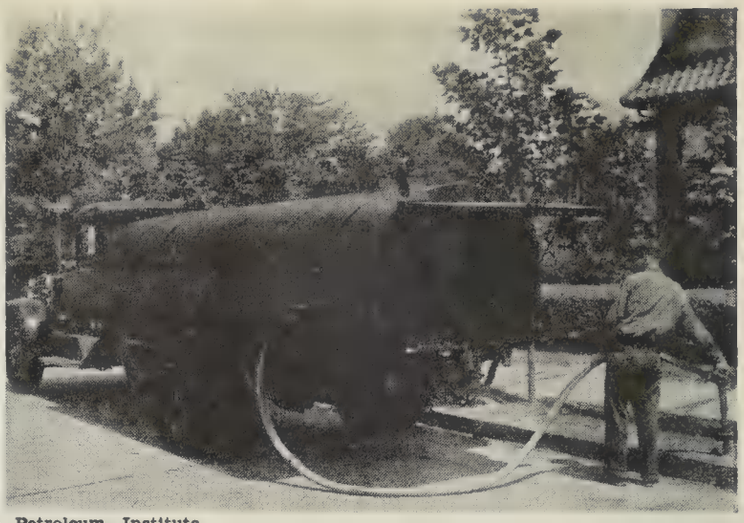
From The William H. Coverdale Collection

One of 50 oil wells drilled in 1860 on Gaspe Peninsula, Canada. Production was small and they were abandoned



Courtesy American Petroleum Institute

Delivering kerosine in the old horse and buggy days



Fuel oil is delivered to homes today by tank trucks

portation. The first successful "long-distance" pipeline was constructed in 1865 by Samuel Van Syckel. It was a two-inch line, five miles long, in the Oil Creek region. In 1874, J. J. Vandergrift and George W. Foreman built the first trunk line—60 miles of four-inch pipe from the Oil Creek area to Pittsburgh and four years later work was begun on a line across the Alleghenies to the Atlantic seaboard.

The railroad tank car made its first appearance in 1865, to be followed three years later by the prototype of the present horizontal, cylindrical tank. Tank ships made almost equally rapid strides. The first transoceanic shipment of oil was one of five barrels from Philadelphia to London in 1861. By 1869, the *Charles* was fitted with 59 separate iron tanks with a total capacity of 714 tons and she plied regularly between the United States and Europe. In 1872, Palmer and Company of England built the first tank steamer, the *Vaterland,* for the Red Star Steamship Company of Antwerp and by 1885 more than 1000 vessels were transporting American oil across the waters. The "Lamps of China" were far from being the only ones that burned American oil.

Drilling and production of oil spread rapidly during these years. Oil was found in California in 1866, largely as the result of a report on California oil by Professor Silliman, similar to his 1854 report on Pennsylvania crude. In the east, production spread into West Virginia, Ohio, and Kentucky and later into Illinois, Indiana, Kansas, and Oklahoma. Dry holes were not very expensive in those days of shallow wells; any surface indication of oil—or nothing more convincing than a hunch—was enough to set off a drilling campaign.

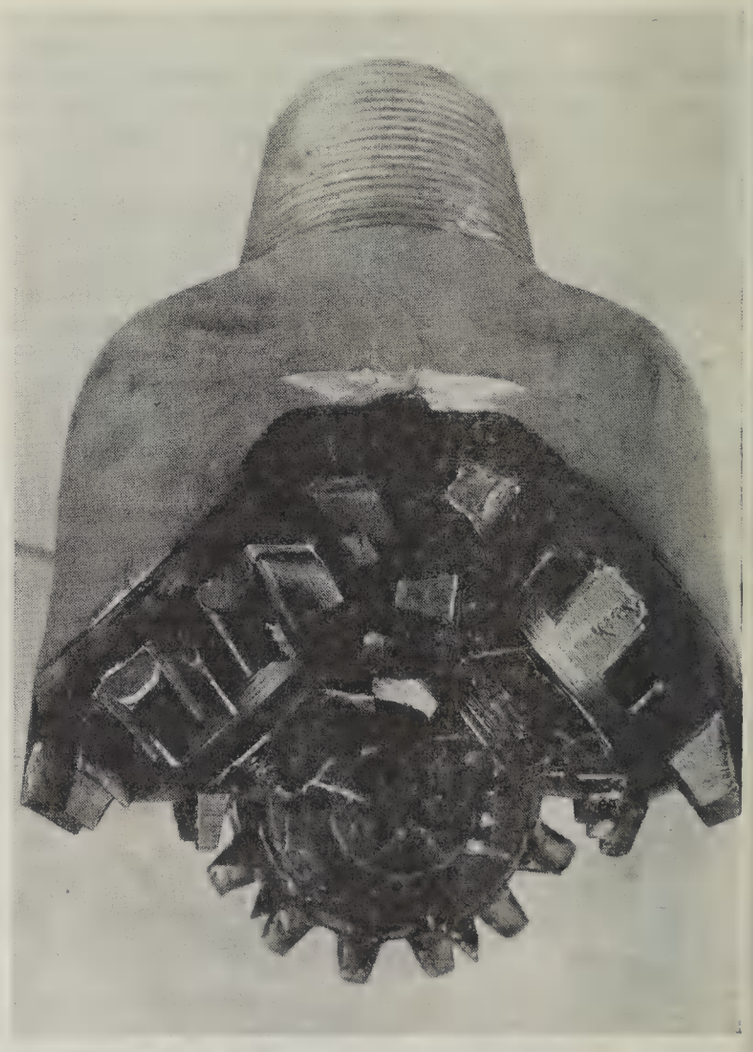
The present-day highly developed science of petroleum geology was practically non-existent, particularly insofar as the average producer was concerned. Men of learning were developing, debating, and expanding the anticlinical nature of petroleum deposits, but knowledge of their findings was confined to the few. All the crude necessary to meet the demands of the kerosine trade and the lubricants market was being produced, so the urge for more intensive exploration was wanting.

GASOLINE ENGINE — Meantime, there was developing in Europe the invention of the gasoline engine, which was radically to alter the entire nature of the petroleum industry and transform the life of the world.

Many men had made satisfactory models of engines based upon the principle of a piston driven by an explosive charge before Nicholas Otto and Eugen Langen brought out the father of the modern gasoline engine in 1877. It remained for Otto to realize, however, the importance of compression in the internal combustion engine. His engine worked and his factory near Cologne was kept busy turning out these new stationary engines.

It did not take long for others to put wheels on the Otto engine. Steam carriages had been made for a hundred years and the application of the gasoline engine to the "horseless carriage" came rapidly. Carl Benz patented his machine in 1886, and Gottlieb Daimler's appeared almost simultaneously. Americans were not far behind. Charles Duryea, Elwood Haynes, and Henry Ford all made cars in 1892. Four years later, these three cars and one made by Benz in Germany were the only four automobiles in the United States. Yet, in 1900, more than 4000 cars were built in this country and in 1910, 368,000 cars and trucks were turned out.

The impact upon the oil industry of the resulting demand for hitherto-despised gasoline was terrific. Men



Courtesy Hughes Tool Company

Today wells are bored miles deep by tri-cone roller-bearing rock bits which cut their way by a rotary motion. Many of these bits are two feet in diameter

hunted long and hard for new oil fields and found them. The national production of 30 million barrels in 1882 had risen to 63 million in 1900 and by 1910 had reached 209 million barrels.

Even this greatly increased production of crude oil failed to meet the growing demands for gasoline available from the simple distillation methods then in vogue. "Straight run" gasoline, as it was called, is produced by heating crude oil and condensing the resulting vapors. More gasoline was needed than this method could produce.

The gasoline supply situation was tight when, in 1911, Dr. W. M. Burton patented the "cracking" process and



Courtesy Standard Oil Company (N. J.)

Gigantic hooks, taller than a man and weighing several tons, are used in modern drilling operations

the first cracking plant was built at Whiting, Indiana. This method, in effect, subjects crude to both heat and pressure so that larger molecules in the crude oil—unsuitable for motor operation—are broken up into smaller molecules that work efficiently in a gasoline engine.

SCIENTIFIC METHODS — As the demand for crude oil rapidly increased, producers sought the help of science in determining where to drill. Easily-found fields were becoming far less common. Drilling costs, as deeper holes became necessary, went up. So, slowly at first but in ever-increasing numbers, the petroleum geologist became a man of prime importance in the industry. He mapped areas of petroleum promise, looking for evidences of the folding and faulting of rock structures that form oil traps. He studied rocks for porosity. He brought the physicist, the paleontologist, and the engineer onto his team so that the search for oil became a painstaking and precise, if not an exact, science. With his help, more than 400,000 wells are producing oil in the United States today.

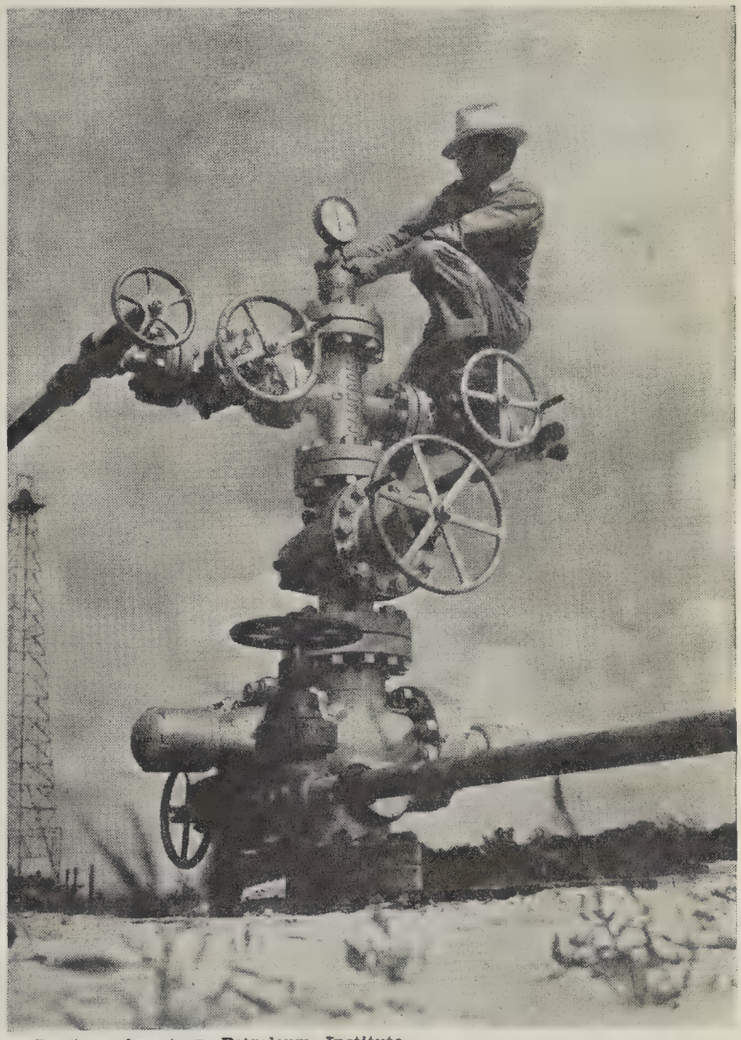
The years from 1910 to the outbreak of the recent war were ones of steady progress for the petroleum industry. Scientific exploration replaced the hit-or-miss methods that had gone before. The seismograph and the magnetometer came into general use and the search continued for an exploratory device that would disclose the definite presence of oil instead of merely locating formations that might or might not contain it. That device still remains to be found, however, and only the drill actually discovers oil.

Great progress was made in drilling methods. While the rotary drill has, to a considerable extent displaced the older percussion or cable-tool method, both remain in use. Rotary equipment has grown heavier through the years and has been vastly improved in many respects. It is the rotary drill that makes possible the deeper wells of today. The world's deepest drilling in Texas, is more than three miles down—16,555 feet, at last reports—and the world's deepest production is from a Louisiana well, at 13,520 feet.

For many years one of the bugbears of drilling was the crooked hole. As the bit went down it frequently was deflected by hard rock formations and the resulting "bottom hole" might be as much as 1000 feet to one side of its surface opening. Science changed that during the '20s by a number of devices, including underground photography, that enables the driller to determine exactly where his well is going and to correct deviations. In addition, by use of a weighted bit, directional drilling is now possible, enabling wells drilled on land to tap oil formations under the ocean, lakes, or rivers. These are only a few of the thousands of inventions that have made possible precision drilling thousands of feet into the earth's surface.

Equally great progress has been made in the production of oil. In the older fields, from 20 to 30 percent of the crude in a given formation was recovered. Today, 70 to 80 percent is brought to the surface. Again, every branch of science has been used to achieve this result.

Conservation practices now in vogue, under state



Courtesy American Petroleum Institute

Devices known as "Christmas Trees" eliminate the spectacular, wasteful "gushers" in oil fields today

laws, are of great importance in making this increased recovery possible. These practices prohibit the indiscriminate drilling of wells, dissipation of gas pressures, and wasteful production. They are designed to provide the largest possible total recovery of oil from underground formations rather than immediate flush production.

Another outstanding contribution to oil production was the perfection of the "Christmas tree" connection, so named because of its many arms and branches. The "Christmas tree" has ended, almost entirely, the wild well that was for many years a feature of the oil field landscape. The "gusher" is a thing of the past. When a well comes in nowadays, regardless of size, pipe connections already are in place to keep it under constant control.

ENGINES AND FUELS — The spectacular advances made in refining, both of motor fuels and lubricants, are well known. Improvements in gasoline engine designs consist largely of increasing the compression ratio; that is, increasing pressure in the cylinders in which combustion takes place. This gives more power from the same size engine with a smaller consumption of fuel. As motor designers and petroleum refiners learned that the motor must be geared to the fuel, and vice versa, for efficient performance, they "teamed up" in their research activities. Steady improvements in the cracking process made possible gasolines to fit any motor design. Engine lubricants were improved by additives that increased their adhesiveness to metal and controlled their viscosity. The general trend just before the outbreak of World War II was more and more away from ordinary gasoline and lubricants and toward synthetic or "built up" products that render better performance.

At the same time, the number of products obtained from petroleum, other than gasoline and lubricants, increased enormously. A modern refinery makes some 2000 products, from which thousands more are made by other processors. For more than a decade, every household and every industry has depended directly, in one way or another, upon petroleum products in some of its myriad forms.



From Scientific American

The picturesque days of the "gusher" gone wild are a memory of the past, due to modern control methods



Courtesy Standard Oil Company (N. J.)

Opening huge control valves that regulate flow of oil from tankships into storage tanks seen in rear

While the oil pipeline had its genesis in the 1860's, tremendous pipeline development took place in the 20's and 30's. Today, a network of approximately 150,000 miles of main trunk pipelines stretches throughout the country, and thousands of miles of gathering lines extend through all the nation's oil fields. By 1941, a marketing system had been built up that employed some 750,000 persons and had more than 300,000 retail outlets in every section of the country.

Thus, at the outbreak of the greatest war in history, the petroleum industry was a strong one, with the men, the materials, and the "know how" to produce many and varied products. No one had any inkling, however, of the industrial miracles the petroleum industry would be called upon to perform in the recent war.

The first was aviation gasoline. Only two refineries in the United States made 100-octane gasoline before the war, and the 35,000 barrels a day which they turned out was ample for all civilian and military demands. The armed services suddenly demanded 100-octane fuel in vast quantities. Processes with which researchers had been experimenting in their laboratories were rushed to full-scale production. Every refinery in the country was assigned some part in the great task and development went on at a feverish pace. One-hundred octane, the supposed perfect gasoline from an anti-knock standpoint, has been topped so frequently that the motor fuel which powers a B-29 Superfortress, for instance, can hardly be called gasoline in the usual sense. Triptane (2, 2, 3-trimethyl butane), the newest laboratory wonder fuel, gives four times as much power as 100-octane gasoline and has been developed so rapid-

Birth of Petroleum



■ Life moved at a leisurely pace in 1855 when R. T. Crane first opened his little foundry. The horse-drawn carriage was the last word in private transportation; clipper ships with their spreading sails were deemed fast enough to carry the world's cargoes; and chugging locomotives transported their freight only as far as the brawling frontier towns on the Mississippi.

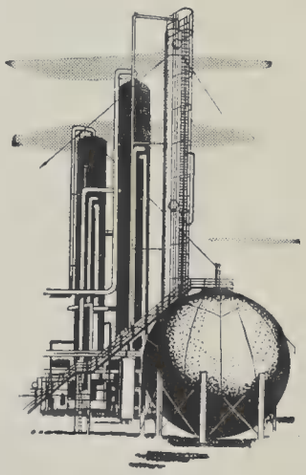
But 1859 marked an end to the leisurely life our forebears knew, for in that year a foresighted pioneer broke the soil of Pennsylvania and out gushed a stream of oil. Almost unnoticed at the time, this development denoted the birth of our modern age of speed, for from it stemmed such forms of transportation as the family car—the giant Diesel locomotive—the airplane—and the luxury liner.

The petroleum industry—typified by wells that bore three miles below the earth's surface—by the huge refineries whose daily output is measured in millions of barrels—by the giant pipe lines carrying gas and crude half way across the nation—has come a long way.

And at every step in this progress, Crane has shared in this triumph, matching the technological development of the industry with new valves and fittings designed to withstand ever increasing pressures and temperatures.

1945 marks Crane's 90th anniversary—90 years devoted to meeting the demands of all industry for better piping. Today, the Crane line includes everything a buyer of piping can want; and Crane distribution, nation-wide in its scope, serves every section of the country.

CRANE CO., 836 South Michigan Avenue, Chicago 5, Illinois



Today's cracking plants represent a vast improvement in refining technology. Crane has played ■ leading role in developing piping equipment that has made these new techniques possible.

CRANE

90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE

PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS



Courtesy Standard Oil Company (N. J.)

Working on an oil drill collar. Threaded ends of pipe lengths must be carefully joined to insure the successful operation of the well-drilling equipment

ly that motor designers have not been able to perfect an engine to use it. It is employed now to blend with lower grades of aviation gasoline to improve their quality.

American refineries at the close of the war were making more than 500,000 barrels of aviation gasoline a day, 85 percent of the world's production.

War suddenly called for lubricants that would work equally well in Greenland or on an equatorial island. A plane standing on the North African desert, for instance, might take off from an airport where the temperature stood at 140 degrees, Fahrenheit. In a few minutes it would be in the stratosphere where the temperature stood at 60 below. No lubricant had ever been designed, for quantity production, that would perform under those conditions. It was vital to the war, so this nation's petroleum scientists produced it—as they did many another "impossibility."

The list of war-time petroleum industry accomplishments is long: synthetic rubber; rust preventives; DDT, the wonder insecticide; vast quantities of fuel oil for our mighty Navy; asphalt for temporary landing fields; and a hundred others. A case in point is that of Diesel fuel. Just prior to the war there was approximately 10 million Diesel horsepower in operation in the United States; by the end of 1944 it totaled 80 million horsepower and the needed fuel was available.

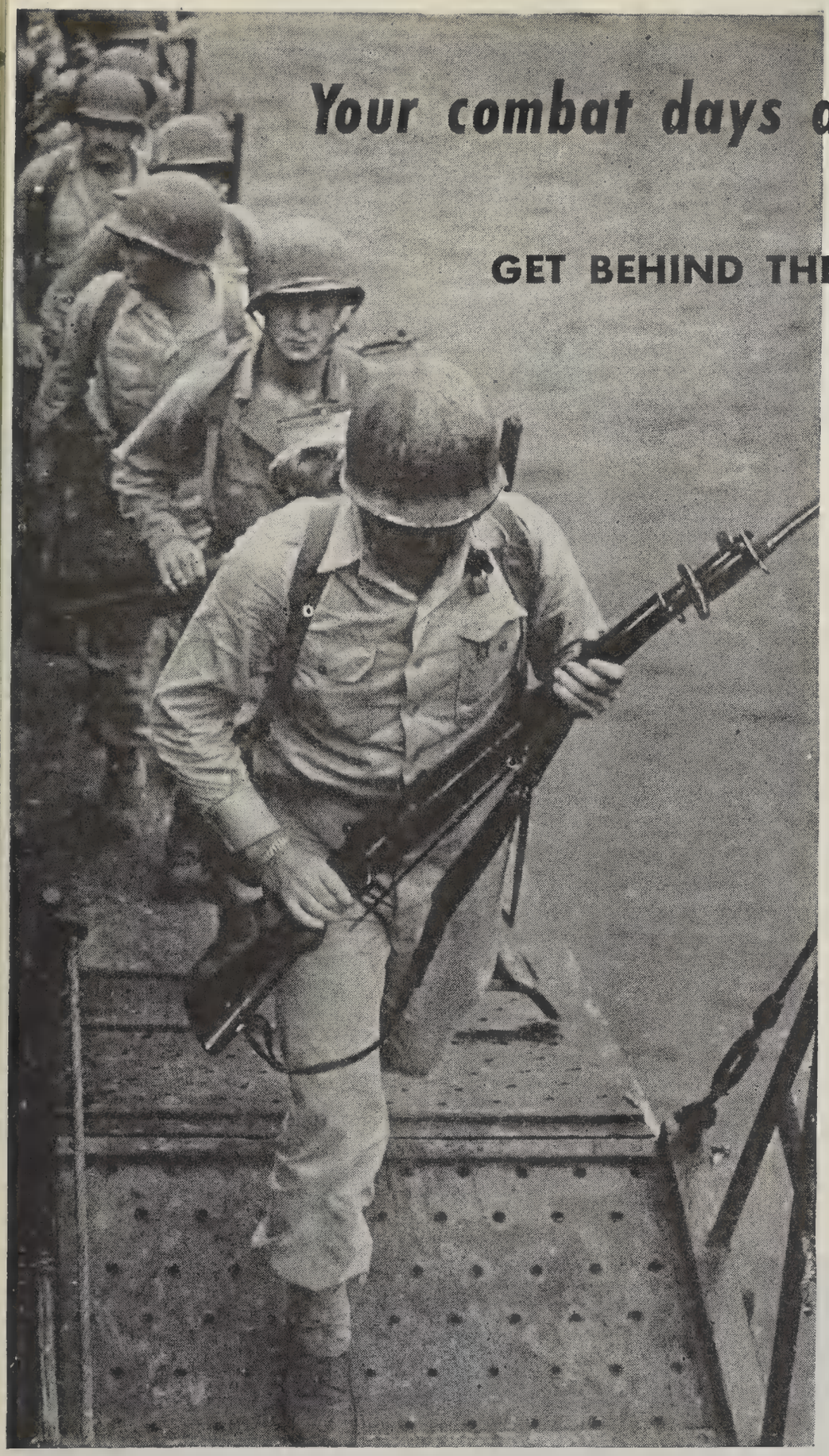
The American petroleum industry "oiled" World War II as it did World War I. In 1918, the military forces of the Allies consumed about 39,000 barrels of gasoline per day. In World War II, the daily military gasoline demand reached 800,000 barrels, and gasoline is only one of many products which modern war requires of the petroleum industry. This tremendous demand, with the United States supplying 69 percent of all petroleum products, has had, of course, its repercussions upon all phases of the industry. Production reached an all-time record of 1,678,000,000 barrels of crude in 1944. This was achieved in spite of manpower and material shortages of serious proportions.

HYDROCARBON CHEMISTRY — Today the petroleum industry looks ahead to a new and vaster usefulness, based upon hydrocarbon chemistry. Science has solved the secret of the hydrocarbon molecule, and a great new vista of synthesis has opened up. The fuels and lubricants of today are synthetics, chemically arranged for the best possible use of the tremendous energy locked in petroleum and natural gas. In addition to these, there are hundreds of new chemical products in the making, based upon synthesis of the hydrocarbon molecule. The industry is convinced it is standing on the threshold of great achievement—a tribute to its leaders who never have hesitated to spend millions of dollars, year in and year out, for scientific research.



Courtesy [illegible] Company

Partial view of one of world's largest oil refineries. It covers 640 acres. The three giant catalytic cracking units are of skyscraper height. Besides other products, this refinery produces over 70,000 barrels of gasoline daily



Your combat days are not over!

GET BEHIND THE VICTORY LOAN!

There's plenty of action ahead for fast-thinking industrial leaders in putting over the new Victory Loan! Your Victory drive is important because:

EVERY VICTORY BOND HELPS TO

1. Bring our boys back to the America for which they were willing to give their lives!
2. Provide the finest of medical care for our wounded heroes!

BOOST THE NEW F. D. ROOSEVELT MEMORIAL $200 BOND!

Urge all your employees to buy this new Franklin Delano Roosevelt Memorial $200 Bond through your Payroll Savings Plan! At all times better than ready cash, Victory Bonds are industry's "Thanks" to our returning heroes!

START YOUR VICTORY DRIVE TODAY!

Every Victory Bond aids in assuring peacetime prosperity for our veterans, our nation, your employees—and your own industry!

The Treasury Department acknowledges with appreciation the publication of this message by

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Scientific American

★ *This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and War Advertising Council* ★

Precision Quenching

By Control of the Pressure, Temperature, and Turbulence of Quenching Mediums, Engineers Have Made it Possible to Predict, With High Accuracy, the Exact Amount that Metals Will be Distorted by Heat Treatment. Through Use of these Methods, Machining Time Can be Reduced

WHEN makers of metals shaving machines announced that they could predict within a few ten thousandths of an inch the amounts and directions in which metal parts would warp and change dimensions when being heat treated, they added one more bit of evidence to the belief that precision quenching will bring a brand new era to the metals fabricating arts.

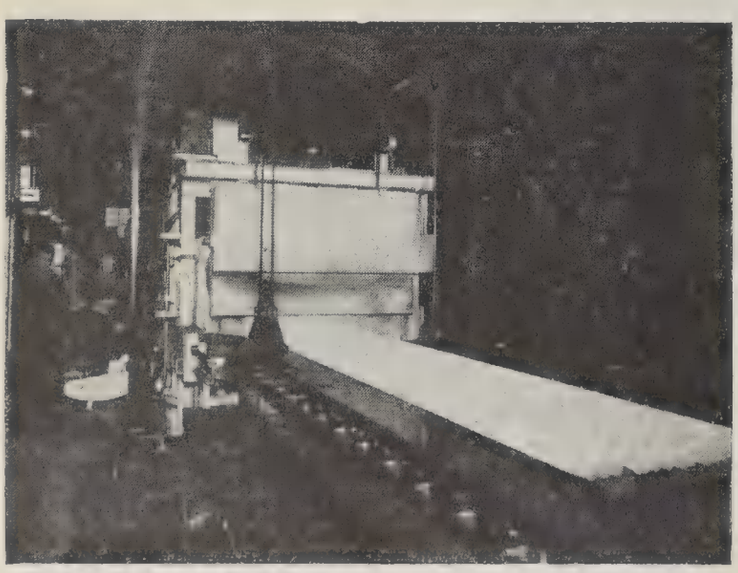
Precision quenching is itself an application of machinery to establish and control the shapes and sizes of finished pieces. It is a mechanical engineering art. But it is mechanical engineering wed to metallurgy. And its real effects will extend far beyond the development and use of equipment for its own operation.

To the extent that precision quenching proves practical, every production machine from the humblest lathe or drill press to the most highly organized automatic will find the work assigned to it affected. Grinding and lapping—those final operations of super-finishing and of ultimate accuracy—will be displaced from one operation, be given brand new opportunities to improve another.

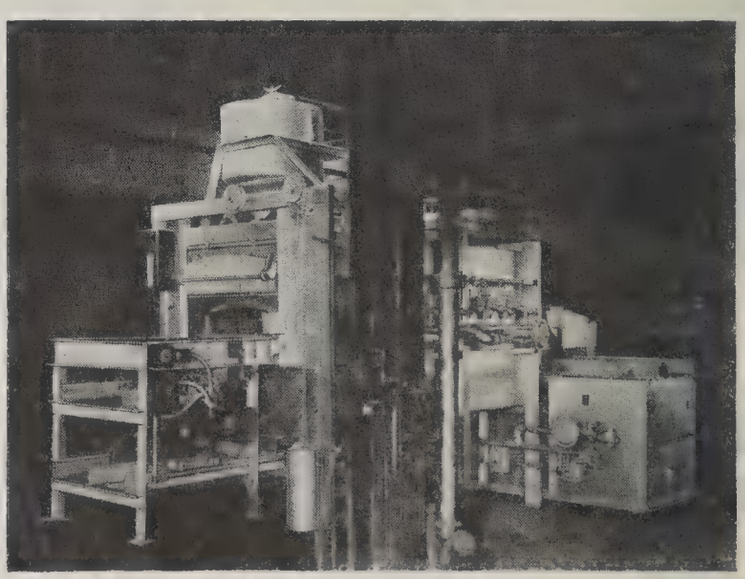
Product designers will select materials and design parts in shapes which never before were practical for production lines. The metallurgist will move still farther out of his cloistered laboratory (he has been inching his way out of there for a long time) and still closer to a post along the production line.

The process of quenching has been known for thousands of years. The steel or other metal part is heated to a temperature which varies with the material. As it approaches this temperature it goes through a "critical range" during which its granular structure changes. If it is then allowed to cool slowly enough the granular structure may change back again. But if it is cooled quickly enough the granular structure can be trapped in its changed condition. Then the metal, in accordance with its nature and the way the whole heat-treating operation was carried out, will be harder, stronger, more elastic, or have other characteristics which are more desirable for its purpose than the ones it had before it was heat treated. The quick cooling is accomplished by plunging the heated part into water, oil, air, salt compounds, soft metals, or other media; this operation is known as quenching.

MORE USES—It is not surprising that the makers of precision shaving machines and of other equipment which machines so accurately that final grinding of parts can be eliminated, should be among the pioneers in precision quenching. Precision quenching aims at the accurate control of surface finishes, dimensions, and contours of parts as well as control of granular structures and characteristics. If the surfaces and dimensions are changed by non-precision quenching then they must be restored — and in some cases created — by grinding. This means that many a part will not be finished accurately until after it has been quenched, since that accuracy would only be destroyed by the heat treatment. Thus, accurate machining proponents could even be opposed to the need for leaving enough "grinding stock" so that no matter how the



Courtesy Bethlehem Steel Company
Hot metal bars being removed from high temperature chamber of heating furnace onto quench tank rollers



Courtesy Surface Combustion
Hardening metal parts without brittleness may be done on the production line by quenching in molten salt

part might warp in the quenching it could still be ground true to size and shape. But with precision quenching the parts can be machined accurately before hardening and high-accuracy machining equipment will find more employment accordingly.

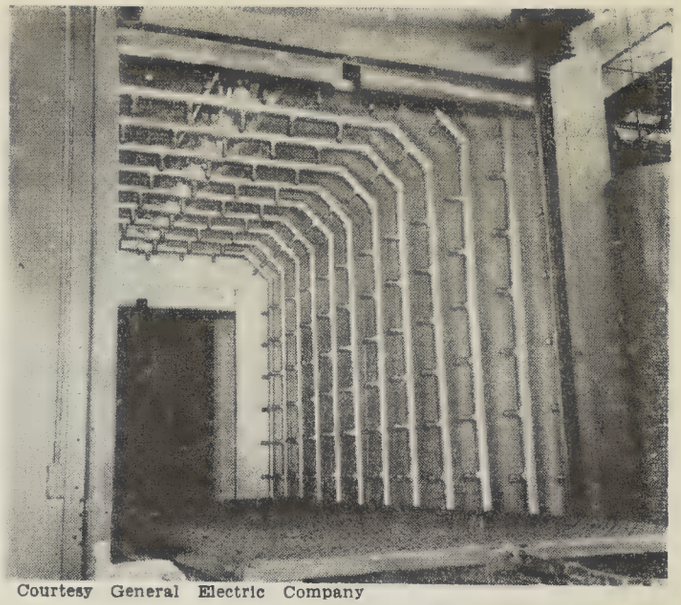
Hard on the heels of these machine makers are the producers of inexpensive plain carbon and "low" alloy steels and of aluminum, magnesium, and other alloys. There is many a low cost alloy which could be given hardnesses and other characteristics good enough to enable it to displace higher cost alloys if only it could be quenched without warpage, internal weakening, or outright breakage. Moreover, the higher cost "high" alloys could find brand new fields of usefulness if this same quenching problem could be solved for them.

Warping and other deforming is almost entirely a function of the speed with which the heat is removed from the part. Usually the entire part is heated, although there is some "skin hardening" in which only the surface of the part is heated before being quenched. But in any case the heat must travel from its innermost penetration out to the surface of the part and then be removed. If a part has thin sections integral with thick ones (example: the teeth of a gear integral with its main body or hub) then the heat will tend to travel out of the thin sections while the thick one is still very hot, and the teeth may warp. But if that same gear can be so quenched that the thick part and the thin parts cool at rates which are not out of satisfactory balance with each other then the warpage can be held within controllable limits.

And those amounts of warpage, together with their directions, can be predicted. Thus the art of precision quenching becomes one of foretelling exactly what the warpage will be and of allowing for it, and quenching becomes a means of making planned changes in dimensions and contours of parts — an art to take its place beside those of machining and grinding as a means of obtaining final shapes and sizes.

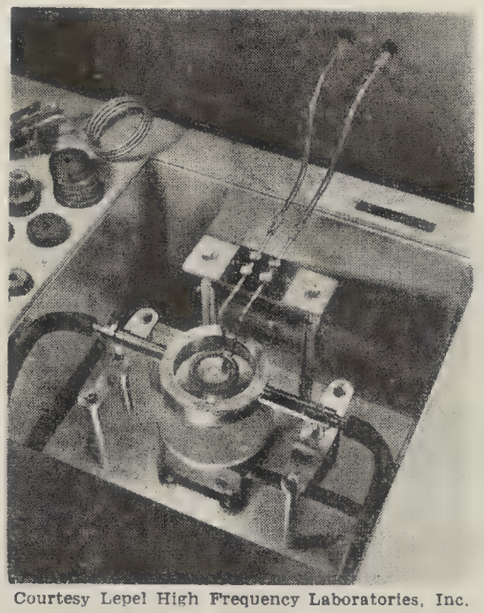
Side by side with the warpage problem is that of the natures of alloys. If heated above their critical ranges and then plunged into cold water, some high alloy steels would literally explode into small fragments when their exteriors cooled and contracted much more rapidly than their interiors. Some low alloy or carbon steels, by contrast, fail to harden because there is no quenching medium which will remove their heat rapidly enough. Between these two extremes, various alloys can acquire all sorts of locked up or residual stresses during quenching operations. The locked up stresses may not warp or break the part at once, but they will cause it to warp or "creep" gradually over a period of years or they will make their presence known by warping the part the first time it is machined, strained, or slightly injured so as to afford the stresses a path of escape. And all of these problems are related to the speeds with which quenching mediums remove heat from the parts. So the precision quencher must predict the exact amount and direction in which the part will warp or change in size, must make the part so that after warping it will be to the required size and shape within a few ten thousandths of an inch, and must do all this while respecting the behavior of the alloy of which the part is to be made.

Right: "Jet" quench nozzles in roller-hearth electric furnace



Courtesy General Electric Company

Below: Gear revolves in heater coils during automatically controlled heating and quenching cycles



Courtesy Lepel High Frequency Laboratories, Inc.

MODERN MEDIUMS—The first resource of precision quenching is the wide list of modern quenching mediums. It is the boast of large oil companies and other makers of quenching mediums that they can give the metallurgist any quenching speed he wants, from the extremely rapid one of wetting-out additives in water to the extremely slow ones of lime and asbestos products, with all the speed gradients of various oils in between. The medium can be suited to the desired speed.

Mechanical control of the entire quenching operation is the second but by far the more important resource. In fact, precision quenching depends far more upon mechanical engineering than upon outright metallurgy.

The temperature of the quenching medium must be controlled mechanically. This is largely because the speed with which the medium quenches is largely dependent upon its temperature. Quenching involves the transfer of heat from the metal to the medium, and since the rate of heat transfer is directly affected by the temperature difference between the hot and the cold body, a heated medium (medium for medium) will quench more slowly while a cooled one will quench more rapidly.

Viscosity of an oil, or of any other medium which is subject to wide changes in viscosity, will be affected by temperature. And the quenching speeds of oils can vary widely with their viscosities. Furthermore, the viscosity of an oil affects the ease with which it can be caused to impinge upon all surfaces of the metal part simultaneously or to reach selected surfaces in selected sequences, whichever is desired; heavy bodied oils are much harder to control in this respect than light bodied.

Water and oil vary directly in the effects of their gasifying when used as quenching mediums. The steam from water has less cooling ability

than the water but the vapor from oil has slightly more than the oil itself. The water therefore may be used at the coldest practical temperature so as to increase the amount of heat it will take away from the metal before turning into steam, while oil is quite commonly used at temperatures ranging from 110 to 120 degrees, Fahrenheit.

One effect of gasifying is that the medium will impose one cooling rate where it is striking the metal as a liquid and another where it is impinging as a gas only. Control of this factor is among the newest and least developed arts of precision quenching. Water may be mixed with such additives as sodium chloride to decrease the rate at which it will gasify and thus increase the net area which it contacts as a liquid — thus increasing both the speed and the uniformity with which it will quench—or it may be mixed with soaps and other additives to achieve the opposite effects. Oil may be fed at varying temperatures to change the areas impinged upon by liquids and gases — shop men say "for every oil and every job there is an ideal temperature" — and it, too, can be varied in its action by the use of additives.

SPEED REDUCED—Oil under high temperature conditions will oxidize, with the result that its quenching speed is reduced. Large batches of quenching oil, as much as 5000 gallons at a time, have had to be discarded for this reason. Oxidation inhibitors can be used, but tests have shown that after the oils have been held for more than two or three hours at greatly elevated temperatures, some of the most common of these inhibitors lose their effectiveness and the oils oxidize just as rapidly as if they were not present. This is just one more reason for the mechanical control of the temperature of the quenching medium.

In precision quenching, materials handling must be exact. Parts must be taken from the furnaces or other heating means to the baths with minimum exposure to the air. They must be held in exactly the right positions and go through the bath or be exposed to the jets of quenching medium while travelling at the correct speeds.

Cleaning of the parts to be quenched is another mechanical engineering function. Research has shown that any fine chips or other "metallic dirt" placed in the oil bath at quenching temperatures will act as a catalyst to hasten the oxidation of the oil. This has definitely been proved for alloys which contain any iron or copper, but aluminum and magnesium are suspect as well. Lead is a catalyst; it must not get into the bath. Any shop dirts can be contaminants.



Courtesy Rustless Iron and Steel Corp.
Stainless steel being subjected to regularly conducted pilot tests to determine response to heat treatment

TURBULENCE—Feeding of the oil to the parts to be quenched is one of the most important mechanical engineering functions. Turbulence in heat transfer from metals to liquids is a vital aspect of the problem. It has been shown that oil can be made to approach the quenching speed of still water if directed against the work with sufficient pressure and turbulence—that those factors of pressure and turbulence alone can multiply the quenching speeds of various mediums by three or, through control, by any desired amount up to three. Many engineers prefer to use just one quenching oil for all of their work and to vary its cooling speed by the temperature, pressure, and turbulence with which it is fed.

Often the solution of a quenching problem is to direct a stream of the quenching medium at some one part or area of a part, or at selected or successive areas, before the part as a whole is quenched. Tricks like these bring quenching into the realm of the designing and operating of quenching machinery. Modern precision quenching, then, is a marriage between metallurgy and mechanical engineering, with the metallurgist saying what is to be done and the mechanical engineer showing how. And this new art may change many phases of metals production and machine design.

• • •

STIFFENING SHEETS

Can be Accomplished by Backing or Denting

IT IS nearly impossible to bend the edges of large sheets of thin metal without bulging or curving the main or "flat" areas to some degree. Even when dead-soft sheet stock is used there is some spring-back of the sheet after making the bend at the edge, and if the unbent area is large enough this spring-back will appear as slight curvature near the edges.

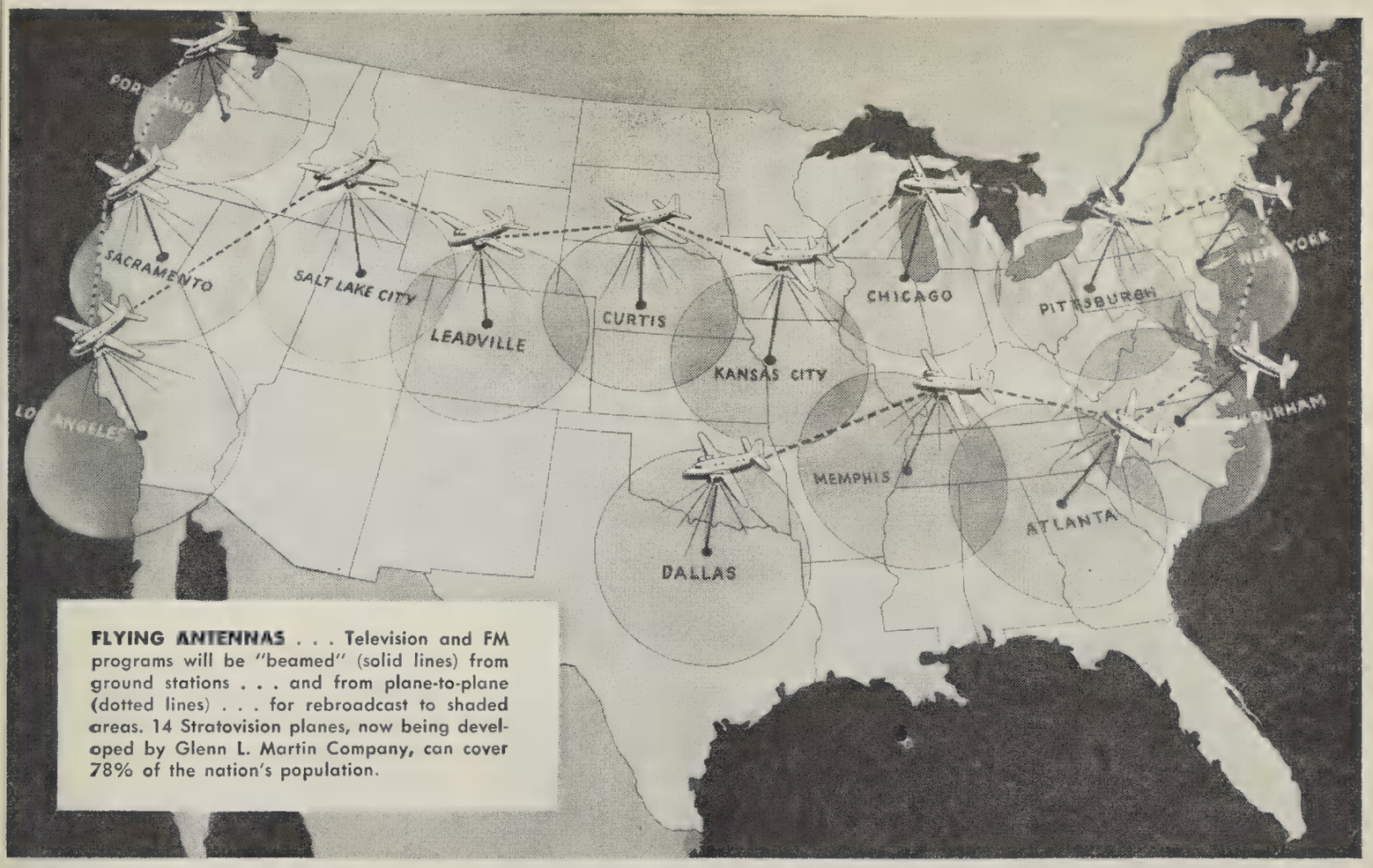
In most cases the only damage done by this bulge is that the metal makes a slight noise when anything presses against it—that noise often being called the "oil-can effect" because it is caused by the same action that makes the well-known noise of pressing a thumb against the bottom of an ordinary oil can. But this noise almost never is desirable and in some cases (for example, the large thin sheet surfaces of airplane parts) it can be highly undesirable.

One way of removing or minimizing the noise is to fasten the thin sheet to a thin but stiff backing material such as plywood. Here the modern glues are valuable. They will hold the metal to the wood while compensating for the differences of thermal expansions and contractions of the two materials.

Another way is to corrugate or otherwise bend the metal to stiffen it and reduce its motion under pressure. And here many new techniques are being developed.

Rather than going to the extreme of actually corrugating the sheet, special pressing dies are used to put slight bends or dents into the flat area after fabricating or shaping the edges. Corrugating could have the disadvantages of adding to the total weight of sheet necessary to cover a given area, or of providing hollows in which dirt could be entrapped or by which air resistance would be increased. Controlled bending or denting can minimize if not eliminate such disadvantages while adding the exact degrees of stiffness desired. The areas to be dented can be selected in many cases to reduce further the disadvantages of irregularities of surface.

Like so many techniques originally developed for aircraft, this one can have important effects upon other industries. It can be used to reduce both noise and cleanliness problems in ducts, chutes, bins, and louvers. Sheet metal roofs can be made less noisy during rain and hail storms; machine guards quieter when machines vibrate.



FLYING ANTENNAS . . . Television and FM programs will be "beamed" (solid lines) from ground stations . . . and from plane-to-plane (dotted lines) . . . for rebroadcast to shaded areas. 14 Stratovision planes, now being developed by Glenn L. Martin Company, can cover 78% of the nation's population.

How Westinghouse STRATOVISION took the final headache out of Television and FM

EVEN before the war ended, Television and FM transmitting and receiving equipment had reached a high degree of perfection. But a final difficulty remained—the problem of broadcasting such programs on a *nationwide basis.*

Because of the ultra-high frequencies employed, Television and FM waves travel only in straight, "line-of-sight" direction. They do not *bend* around the earth's surface . . . as do those of standard-band radio.

This limits the range of a Television or FM station to a *maximum of 50 miles*—even when perched atop the tallest building.

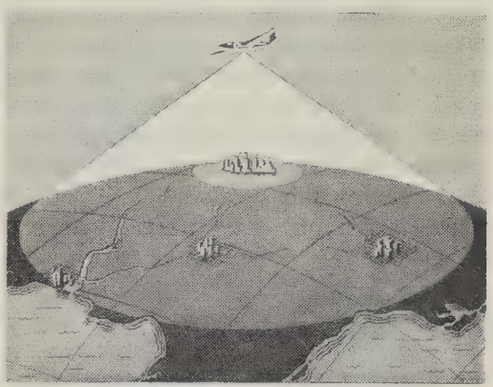
A chain of radio-relay stations across the country—or coaxial cables spanning the nation—have been proposed as a solution. But these are terrifically expensive and, worse yet, cause serious distortion of long distance programs.

Now, at last, Westinghouse research engineers have discovered a practical solution through "STRATOVISION"—broadcasting Television and FM programs from *planes flying six miles high in the stratosphere!*

At this altitude, a single Stratovision plane can cover an area 422 miles in diameter . . . 103,000 square miles . . . approximately the combined area of New York, New Jersey and Pennsylvania.

Westinghouse engineers predict that 14 of these flying broadcasting stations can transmit 4 Television and 5 FM programs simultaneously to *78% of the nation's population.*

The conception and planning of Stratovision broadcasting are a tribute to the ingenuity and engineering "know-how" of Westinghouse radio technicians . . . gained through producing $400,000,000 worth of Radar and radio equipment for our armed forces.



HERE'S THE SECRET . . . Stratovision broadcasting, serving an area of 103,000 square miles, will require only *1/50th as much power* as a 50 kilowatt ground transmitter covering only 7,900 square miles. That's why a *single Stratovision plane* can easily carry and power the equipment needed for simultaneously transmitting 4 Television and 5 FM programs.

Westinghouse
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Tune in: JOHN CHARLES THOMAS—Sunday, 2:30 pm, EST, NBC.
TED MALONE—Monday through Friday, 11:45 am, EST, American Network

Refinery Electronics

Temperature Recorder Aids in Accurate Separation of Compounds Whose Boiling Points Are Very Close Together. Another Electronic Instrument Measures the Thickness of Walls of Pipes and Tanks, and Gages Liquids Heights in Vessels Without Access to Their Interiors

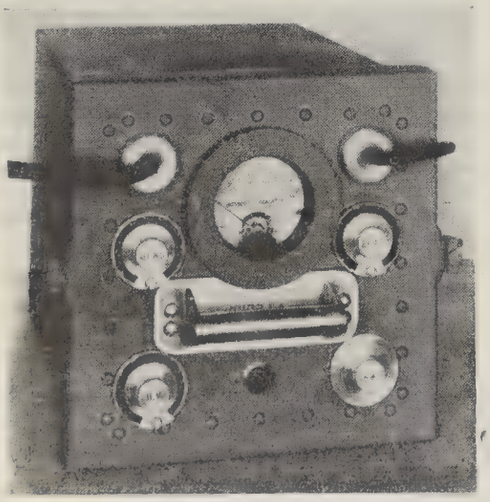
By VIN ZELUFF
Associate Editor, *Electronics*

IN MODERN oil refineries the boiling points of the various constituents to be separated by fractionation must be predetermined accurately. This is now accomplished with an electronic instrument that utilizes electron tubes to magnify small temperature changes.

A high-sensitivity, fine-wire thermocouple, consisting of six individual couples spaced about half an inch apart, is located in the reflux zone of the fractionating column. The voltages produced by these thermocouples are amplified by the electron tubes and recorded continuously by pen on a time-temperature strip chart.

The instrument finds particular application at present in the rapid and accurate analyses of four- and five-carbon hydrocarbons. The special thermocouple covers all possible positions of a wandering condensation ring, which is known to vary several inches up or down in the fractionating column. Thus the true boiling point of a compound is accurately recorded no matter which couple is located in the coldest zone. The Brown Instrument Company's electronic recorder and a special Podbielniak fractionating column makes possible rapid and accurate separation of compounds whose boiling points are only one and one half degrees apart, a feat which cannot be accomplished by older types of apparatus.

To accomplish the perfect blendings necessary in producing 100-plus octane gasoline, Richfield Oil Corporation has installed this electronic equipment in its newly expanded refinery near Los Angeles. The new development considerably reduces distilling time, gives increased accuracy, and opens up a new field in fractional distillation.



Control box of the Penetron. Meter in center gives readings in microamperes

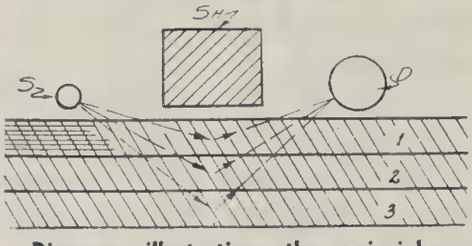
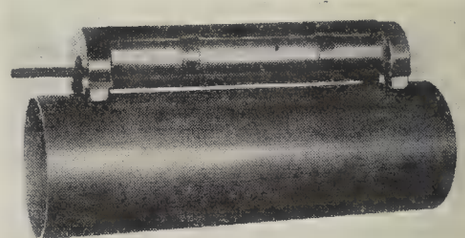
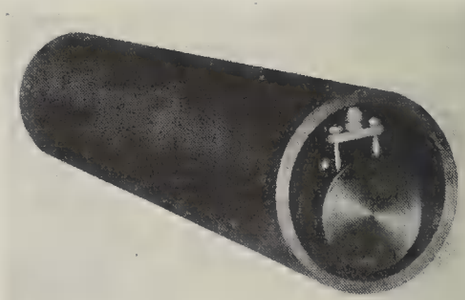


Diagram illustrating the principle of the Penetron. *S* is the source of gamma rays, *Sh* the shield, and *D* the detector, all in the instrument head. Arrows indicate back-scattered rays

THROUGH STEEL WALLS—Wall thickness and liquid level measurements are important in many phases of oil refining. Such measurements can now be made from the outside of sealed vessels with an instrument called the Penetron. This instrument, utilizing electronic and radioactivity principles, can measure wall thicknesses when access can be had to one side only, can gage liquid height and density from the outside of sealed storage tanks, and can be adapted to control levels in process units, such as the solvent-oil interface in a solvent refining tower, or to determine and control the catalyst level in catalyzed chemical reactions—all through solid walls of steel or other material.

The Penetron consists of two main parts—the head and the control box. The head contains the radiation source, the detector, a shield between the two, and a three-stage preamplifier. It weighs about seven pounds and is connected by a cable to the control box which contains a measuring circuit and the power supply. The head is completely sealed in its metal housing, to insure safety in refineries and other locations where explosive hydrocarbons may react to sparks.





Above: Showing how Penetron is used in measuring wall thickness. Magnetic holder secures it outside of pipe. Below: In measuring wall thickness from inside, head is held against pipe by means of a pneumatic holder

In operation, the instrument bombards the tank walls and the material inside with gamma rays which are derived from a needle



Electronic tubes of various types monitor and control many of the vital processes in petroleum refining. Shown below is the new Richfield high-octane refinery in California



containing one milligram of radium in the form of a commercially available salt. These gamma rays travel with the velocity of light, and are not deflected by magnetic or electric fields. Some of the rays are back-scattered by the electrons of the atoms in the material being inspected, so that they emerge from the material on the same side as they entered.

By measuring the intensity of this back-scattered radiation, the thickness of the material, whether it be aluminum, steel, plastics, brass, wood, or other material, can be determined with extreme accuracy. By the same means, liquid levels and liquid densities are found.

The radium source in the Penetron is surrounded with a shield containing a window which directs the beam of gamma rays in the desired direction. The source of radiation, the tank wall, and the detector are set up in accordance with a predetermined geometric arrangement. A metal shield between the radioactive source and the radiation detector prevents direct radiation from entering the detector.

The radiation picked up by the detector creates current discharges which are amplified and integrated to produce a direct current. The amount of current produced is measured by a microammeter.

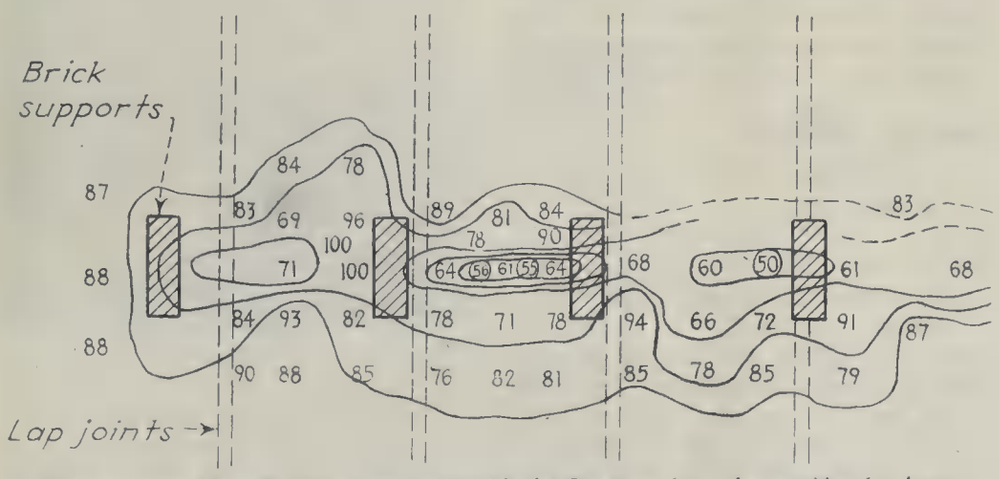
For determining the extent of wear of tubes and vessels due to corrosion, fuming, or erosion, the reading of the microammeter is converted into wall thickness in inches. The instrument is calibrated on specimens of tubing and flat plates having known wall thicknesses. Because the geometrical relationship between the measuring head and the wall changes with the curvature of the wall, the calibration curves for a wall of a given composition will vary depending on the diameter or curvature of the wall or vessel being measured.

Calibration curves are furnished with the instrument. Walls of similar materials produce the same curves. Thus the calibration curves for iron also can be applied to alloyed steels.

Wall thickness measurements can be made on pipes which contain fluids, if a correction is made to take into account the influence of the fluid on the reading of the instrument. This is made simply by establishing a calibration curve for pipes of known wall thickness filled with the same fluid.

The Penetron can be used for measuring iron or steel walls up to approximately 0.75 inch thickness. For other materials the limit is different, being approximately one inch for aluminum. Since the penetrative power of deflected or scattered gamma rays is less than that of the primary rays, rays which are deflected beyond a certain depth are completely absorbed before reaching the surface as back-scattered radiation.

The accuracy of the instrument has been established to be within



Measurements of wall thicknesses made with the Penetron from the outside of a large surge drum. The contour lines are drawn through points of equal thickness; the numbers indicate hundredths of an inch. Severe erosion of the interior of the tank wall is revealed by the presence on the chart of several very small closed contour loops

the limits of plus or minus 3 percent.

The Penetron measures the average thickness over an area of approximately one square inch. It measures the total thickness or volume and not the thickness of any one layer. If, however, a laminated wall is composed of, say, two layers of different materials, the Penetron can be used to measure the thickness of either layer provided the thickness of the other layer is known.

The individual pulses of current created in the detector do not follow each other at regular intervals because the rate of emission of gamma rays by radium is quite irregular. The emission follows certain statistical laws and fluctuates around an average value. The accuracy of the instrument thus increases as the time of observation is increased. The minimum time for each reading is 25 seconds. Including moving the instrument, set-up time, and recording of results, in actual field work it is possible to make measurements at 150 or more points during a working day.

FLUID MEASUREMENTS — The density of a fluid inside a container may be determined directly without access to the fluid itself. In experimental work employing a Penetron situated on the outer wall of a container having a wall thickness of 0.3 inch, it was found possible to check the specific gravities of fluids having values of between 10 and 75 degrees Baume with a high degree of accuracy. This measuring technique can be used advantageously for determining specific gravity of liquids in tankage, routing the flow of oil in pipe lines, control of blending operations in which two materials of different densities are mixed, determination and control of proportions of reactants in chemical processes, and in other applications to determine the density of a substance without sampling or without access to the material.

If the head of the Penetron is placed on the wall of a vessel partially filled with liquid and above the level of the liquid, the amount of back-scattered radiation is due entirely to the wall of the vessel, since the density of the air or vapor in the vessel is negligible by comparison with the density of the material comprising the wall.

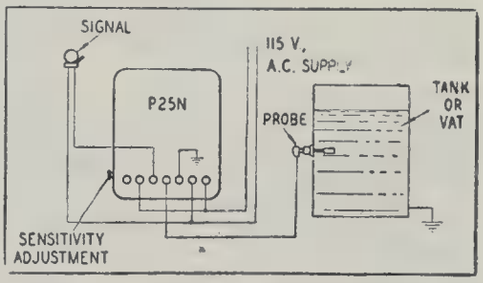
If the head is moved down the wall, the reading of the instrument remains constant until it reaches a point opposite the level of the liquid in the container. At this point, the meter of the instrument will indicate an increase in back-scattered radiation since the radiation passing through the wall is scattered not only by the wall but also by the liquid in the vessel. The point on the wall at which an increase in reading is obtained indicates the level of the liquid. In the same manner, the interface between two fluids of different densities can be located easily and accurately from the outside of a container without actual access to the interior of the container.

By proper instrumentation, the Penetron may be adapted to control as well as to locate liquid levels. In addition, a continuous record of levels may be obtained by employing a recording device.

SOLUTION CONTROL

Made Possible By Electronic Device

CONTINUOUS measurement of the electrical conductivity of a solution, and sounding of an alarm when predetermined limits are exceeded, is now made possible by a unit available in a packaged form from Photoswitch, Inc. Automatic control is easily added, so that the electronic unit will open and close valves or start and stop pumps so as to maintain the concentration at a desired value. A 5 percent change in the resistance of the fluid in the circuit of the detecting probe is sufficient for operation. The voltage at the probe does not exceed 25 volts, which eliminates the possibility of electric shock or explosion hazards.



Arrangement of solution control unit

RAZOR BLADES

Inspected by Photocells

IN AT least one razor-blade factory, the sharpness of each finished blade is checked automatically by an unusual electronic technique. A narrow, intense beam of light is directed at an angle across the shaving edge. Light reflected by dull portions of this cutting edge enters a self-generating photoelectric cell that feeds an indicating galvanometer directly. The sharper the blade, the less light reaches the electric eye and the lower is the meter reading. Automatic rejection of excessively dull blades is but a step further, involving use of a phototube, amplifier, and relay arranged to actuate an electromagnet that knocks a blade off the conveyor if it reflects more than a predetermined amount of light into the phototube.

FILM WIDTH

Now Measured Accurately By Vacuum-Tube Gage

A NEWLY developed vacuum-tube gage is capable of measuring the width of motion-picture film to an accuracy of 0.002 millimeters while the film is in motion, without injury to the film from pressure. A small lever swinging on a bearing has a rounded surface that presses lightly against one edge of the film as it passes through the gage. The lever swings outward and inward as the film width varies, causing corresponding movements of an attached metal disk that forms one plate of a two-plate variable capacitor.

A change in film width is thus converted into a change in capacitance, and this change is amplified electronically by vacuum tubes and made to actuate a meter which is calibrated to read film width directly in millimeters.

METAL STITCHING

Controlled by New Electronic Unit

A COMBINATION electronic and electro-mechanical seam welding control unit has been developed by Westinghouse primarily for stitching together metal sheets. It is being used for the fabrication of such units as oil drums. The duration of each welding pulse can be changed by inserting or removing pins from a 120-hole disk.



Disk of the seam welder or stitcher

Cargo By Air

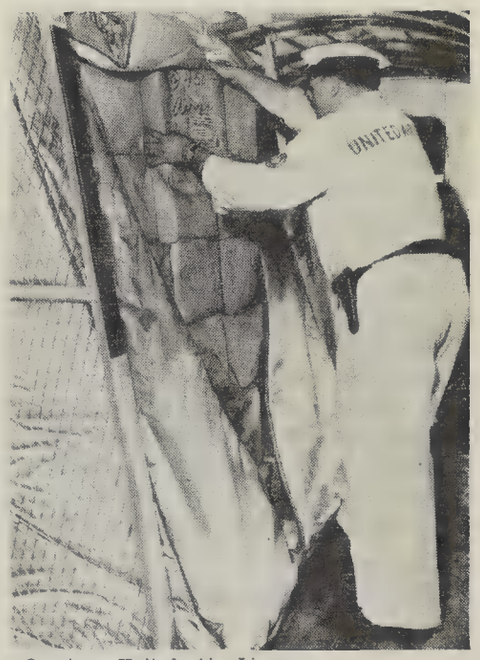
Cargo Airliners of Tomorrow Will Bring Choice Tree Ripened Fruits, Fresh Vegetables, and Flowers from Far-Off Corners of the World in Special Refrigerated Compartments. Many Industries Will Profit by Using Air Freight to Ship Light-Weight and Perishable Merchandise

Most important of the many questions confronting the airlines today are those concerning the amount of air cargo that will be carried in the future and the characteristics of such cargo. Air cargo, according to William A. Patterson, president of United Air Lines, is an all-inclusive term that excludes only passengers and should be applied to passengers' baggage, mail, and what is commonly referred to as express and freight. No matter what definition may be accepted, the answers to the questions regarding air cargo will affect not only the design of airplanes themselves but the whole future of airline organizations as well.

Furthermore, the problems of air cargo interest many more people than just airline executives. Every business man in the country who is concerned with the shipment of goods is almost equally involved. Every shipper wants to know what is coming in the air age—what can and should be carried by air, what rates may be expected, and how reliable the carrying of air cargo will be. These questions cannot yet be answered in definitive fashion, but an examination of the opinions of well informed men, of the statistics which have come from reliable surveys, and of the actual results of carrying cargo by air to date is well worth while.

The air transport operators are most optimistic of the future of their operations in general. In their early expanded post-war fleets, 19 airlines of the United States expect to have 975 planes operating at higher speeds than formerly, with many new comforts, and seating 36,180 passengers. And to raise their equipment to meet post-war programs, the airlines have ordered or have an option on 409 new planes, according to the Air Transport Association. But what is of more immediate interest is that these new planes will have greatly enlarged compartments for cargo. There will be improvements in type and location of hatchways to facilitate loading and unloading. Some of the planes will have quickly adjustable cargo space, so that the number of seats and size of the cargo hold can be varied to accommodate the proportions of the load.

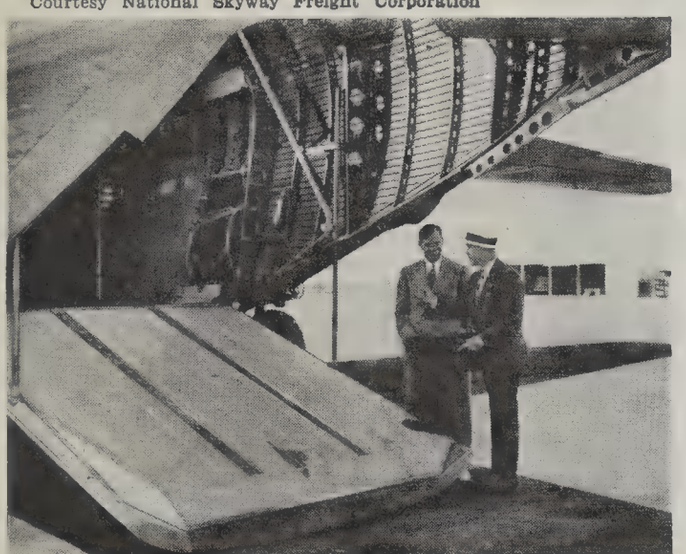
The increase in cargo capacity contemplated is remarkable. The airlines last year carried a total of 202,879,006 pounds of mail, express, and excess baggage. With their new planes, cargo capacity will be increased five fold. They will be able to handle in the coming year *a billion pounds of cargo.*



Courtesy United Air Lines

Shipment of gardenias kept fresh in cooled Fiberglas insulated container

Courtesy National Skyway Freight Corporation



Spacious interior of cargo plane permits handling of many types of air freight—even household furniture

One of the first modern all-cargo planes to be built has a maximum gross weight of 45,000 pounds; a tricycle landing gear; a fuselage floor level with truck floor height and fitted with skid strips and tie-down rings for fast and secure loading. It has a useful load of about 18,000 pounds, a payload of 13,113 pounds at a range of 500 miles, and a cruising speed of 190 miles an hour. The cargo compartment has a storage capacity of 2870 cubic feet and a floor area of 347 square feet. Such cargo carriers will undoubtedly supersede all the converted military transports. It will, indeed, be better for the aviation industry, better for

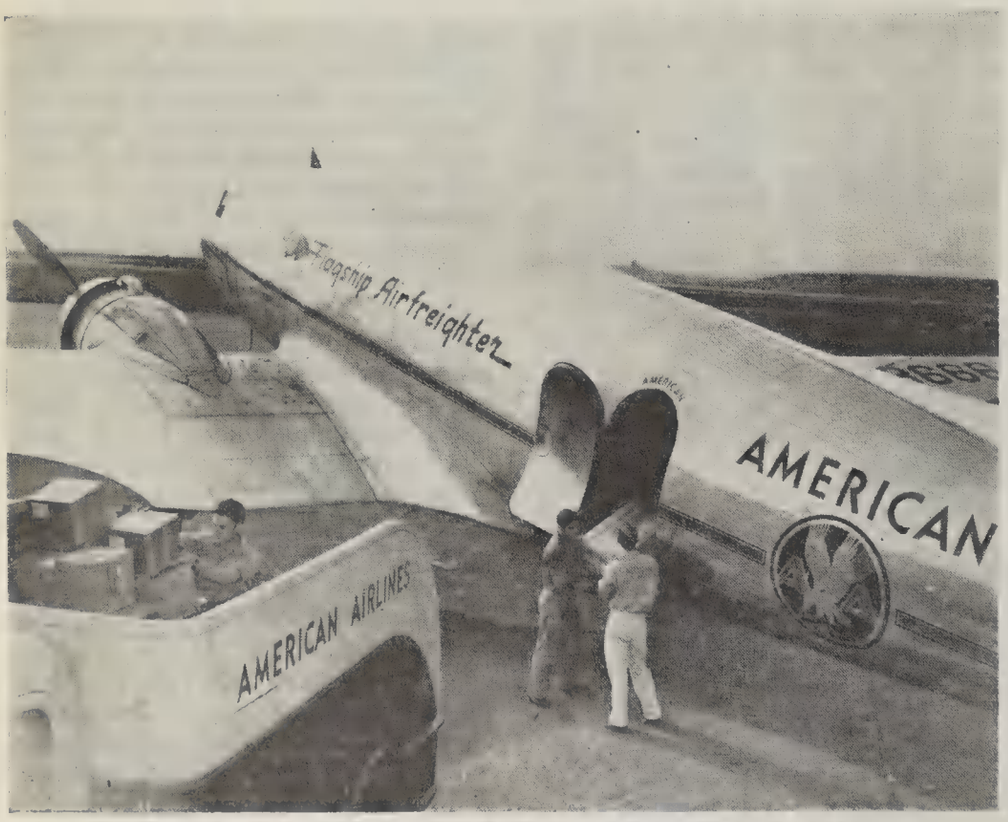
the airlines, and better for the nation at large if the great bulk of military air transport equipment be frankly regarded as obsolete.

AIR CARGO TODAY—What are the airlines already doing in air cargo work? American Airlines (now become American Airlines System since it absorbed American Export Airlines and has undertaken services to Europe) has converted the famous Douglas DC-3 to all-cargo use and named it the "Airfreighter." In the first six months of this year American flew almost two billion air freight pound miles. This is definite accomplishment to back up prophecy or expectations.

Freight by air will be selective in character; it is hardly to be expected that coal will be flown from the mines, or wheat from the western plains. As United's Mr. Patterson has said, passengers when delayed merely grumble; air cargo unduly delayed may turn to garbage! For no class of merchandise is time more important than flowers, the ultimate in perishability. United, working in co-operation with Owens-Corning Fiberglas Corporation, has developed what has been called "a floral ice box."

Gardenias have thus been carried in an airliner, packed in Fiberglas cloth containers insulated with light Fiberglas insulation. Each container weighs 25 pounds and has a capacity of approximately 120 cubic feet. The top is equipped with five pockets which accommodate slabs of dry ice, one inch thick and ten inches square. The walls of the containers are approximately one inch thick and access to the interior is made possible by a zippered opening running almost the entire height of one side. Tests in a United "Cargoliner" were completely successful; 35 boxes of gardenias, weighing six pounds per box, were flown via air-express from San Francisco to Chicago. Cabin temperatures sometimes rose to 100 degrees when the ship was on the ground. Flowers carried outside the refrigerated box became dehydrated; gardenias in the containers arrived in perfect condition.

Of course it may be argued that gardenias are a de luxe commodity which can demand great care and corresponding expense. But does not the experiment warrant a belief that other perishable goods can profitably be carried by air? Claude N. Palmer, of the United Fresh Fruit and Vegetable Association, has a vital interest in the problems of carrying perishable fruits and flowers on a large scale. Mr. Palmer recently said: "I believe I can tell you that the future of all air transport of goods hinges to a greater extent upon a large and continuous volume of perishable soil products than upon any other source of payload. Why? The answer is simply that fresh fruits and vegetables hold a key to the profitable operation of transport planes on their west-to-east and south-to-north flights." Mr. Palmer also reported on the work of the Ralph E. Myers Company, of Salinas, California, which has been conducting test shipments to eastern markets for the better part of a year, and which has launched a program of thrice-weekly air cargoes, the first of which consisted of 18,500 pounds of California tomatoes, plums, apricots, strawberries, and lettuce. These 18,500 pound shipments, the largest civilian freight movement by air ever undertaken, are being made in a new transport plane which was designed and built by Consolidated-Vultee. There will be great competition for the carrying of fruits, vegetables, and flowers by railroads and trucks. But a tremendous potential in air cargo seems to exist also.



Cargo hatches are designed to facilitate quick handling of freight

COSTS—It is too early to speak specifically of costs, and difficult to say what industries will first take full advantage of air freight. The costs will depend on volume and the volume will depend on costs. Air shipment will be expensive for a long time to come, and will have to depend for its development upon greater speed and convenience. But a survey made by the Evans Transportation Research has done a great deal to clarify the situation. When Colonel L. H. Britain launched the survey in co-operation with the Detroit Board of Commerce, he asked but one question:

"If a reliable daily all-air freight service was provided that would leave Detroit at the close of every business day, and arrive at San Francisco early next morning, at a rate of $10.00 per hundred, or ten cents per pound, airport to airport, how much poundage would your company be likely to ship in an average month by such service, for redistribution to Pacific Coast points and for export from San Francisco?"

Replies were promptly received from 30 percent of those firms to whom inquiry was sent and removed a great deal of the guess work which has accompanied industrial thinking about air cargo thus far. The survey indicated that at the above costs, and at the above rate of speed, 200 Detroit factories would ship over 350,000 pounds per month from Detroit to the San Francisco gateway. And this at 10 cents a pound, be it noted, for the long haul.

The three leading shippers by air would be the following, in order: the small tool and die industry; the automobile and automotive parts industry; and the pharmaceutical industry and related producers. The chief reasons given by these firms for regular air shipments were emergencies, reduction of inventories, and the offsetting of local Pacific Coast competition. Other firms saw possibilities of expanding limited local markets. About 200 firms were interested. Negative replies were received from 236 firms who gave as their principal reasons

that the shipper could not commit his customers to increased shipping expense, and that for heavy articles, ten cents a pound might increase cost of the product by a third of its value, which would be prohibitive. It is also interesting to learn that 93 percent of all shipments would be in units of 1000 pounds or more.

FLYING COSTS—On the question of cost, what may be expected from the plane builders whose engineers are busily constructing aircraft of greater size and with lower operating costs? Fred B. Collins, of Boeing Aircraft, summarizes the situation as follows: "There are several ways in which economies of operation can be obtained. One of the most important is by cutting the cost of flight itself, through more advanced performance characteristics which are inherent in the newer airplane design. Another is by designing to decrease the time and cost of maintenance and of ground operations. Increased speed of flight becomes a means of saving cost because it enables the operator to spread his fixed operation costs over a greater number of miles per hour. . . As a result of advances in these various directions, transport planes will be available for immediate post-war use which will operate at as low as 8 mills per passenger mile for standard passenger versions or 4 cents per ton mile for all-cargo versions. These figures compare with operating costs of present type transport equipment in airline use ranging from 1.8 to 2.5 cents per passenger mile and approximately 17 cents per cargo ton mile."

There are other straws in the wind. The Manhattan Storage and Warehouse Company, for example, is experimenting with special air shipping containers for fine china, glass, medicine, and the like. After packing these articles in containers of fiber board, plywood, and so on, they were dropped from a height of 52 feet onto a concrete surface with astonishingly little damage.

Other experiments are being continued on dropping of air cargo by parachute. And Air Cargo Transport is operating non-scheduled charter flights, ready to pick up and deliver by air any special cargoes, of which the recent shipment of 40,000 vials of penicillin to Latin America from La Guardia Field is typical.

POTENTIAL—While fantastic prognostications of air cargo operations that will equal truck or railroad shipments are hopelessly out of line, there is solid support for the conviction that air cargo has a tremendous potential, that it will rapidly find its proper sphere of action, that it will interest a few industries greatly, and almost all industries to some degree. Economists are making reasonable surveys, designers are building better planes and handling equipment, airline operators are making intelligent and courageous bids to industry and business, and business men show every interest in and desire for greater facilities in aerial transportation of cargo.

CARGO DROPPING

From Conveyor Belt in Airplane

THE Air Technical Service Command of Wright Field has developed a conveyor belt for dropping cargo by parachute.

The belt is an endless chain-driven conveyor operated by a 3.87 horsepower electric motor. Power



Air-cargo conveyor

is provided by the 24-volt direct current system which is now available on every plane. The belt extends from behind the pilot's compartment to the rear door of the plane, a distance of 22 feet, and runs at approximately six feet per second, or from one end to the other in four seconds. The belt terminates at a roller-bearing platform mounted at the cargo door. Packages are deflected round a corner and launched in containers from the airplane. Static lines open the parachutes when the containers are 15 feet below the airplane. Not only is speed in dropping increased, but it was found possible to drop 4000 pounds at a time.

The containers each hold 300 pounds, and are carefully engineered. They are made of strong cotton duck and webbing or fiberboard. Another feature of the development is that the area within which the cargo is dropped is very much reduced.

WAR TRENDS

As Foreseen by General H. H. Arnold

DISCUSSING the air war of the immediate past, and the air war of the future, General H. H. Arnold recently made some highly interesting remarks regarding the following "observable trends":

1; Manned or pilotless airplanes traveling at supersonic speeds. At such speeds aerial combat as it is known today would be impossible. 2; The development of guided missiles and the refinement of their controls so that exact hits can be made on targets of a mile square or less, at any part of the world from any part of the world. 3; Improved atomic bombs, destructive beyond the wildest dreams. 4; Great developments in defense both against aircraft and guided missiles. Every new weapon of offense brings forth a weapon of defence, and this should remain true even in the case of the atomic bomb. 5; Perfected communications systems between air and ground, making possible the most intricate maneuvers either by piloted planes or pilotless missiles. 6; Extraordinary developments in the launching and landing and supplying of air-borne troops.

ASPHALT AIRSTRIPS

Surfaced With Prefabricated Material

AIRFIELDS are being surfaced by United States Army Engineers with a new type of material called "P.B.S." (prefabricated bituminous surfacing). The surfaces have taken the steady pounding of fighter and cargo planes as well as medium bombers. The new material is nothing more than burlap, impregnated and coated with asphalt, which gives it the appearance of roll roofing.

One of the unusual features of P.B.S., which is made by the Texas Company, is the ease with which it can be repaired. Small repairs can be made by two men with a mop, a bucket of asphalt, and a strip of surfacing. Swab it, lay it, walk across it, and the patch is made. For larger repairs, such as bomb damage or soft spots formed by trapped water, the surfacing material is slit and folded back, repairs are made to the soil underneath, and the surface is replaced and sealed by adding fresh strips of P.B.S.

How Soon Atomic Energy?

Does the Atomic Bomb Indicate the Future Mass Destruction of Every Living Thing? Or, Properly Controlled, Will Its Limitless Energy be Utilized and Harnessed to Serve Mankind as has Electricity and Water? The Next Five to Ten Years May Possibly Provide the Answer

WHAT may be the beginning of a new era for the human race started on August 6, 1945, when, for the first time on a scale larger than microscopic, the energy of deliberately induced atomic disintegration was applied to the purposes of man. What the characteristics of this new era will be is the most exciting and most important question now before humanity. The possibilities clearly lie beyond present scientific treatment; perhaps they rather belong in that curious realm of super-stimulated imagination, the so-called "comic strips," where stupendous power has long been commonplace.

Will man's future lead through ever-mounting terror and destruction to a climax in the suicide of all living things? Or will this source of tremendous new energy in our hands create the means to freedom, prosperity, and plenty for all men beyond our most sanguine dreams? The problems immediately facing humanity are beyond all question the most serious we have ever encountered. The control of this vast new force poses problems of the highest magnitude and significance in the physical sciences; at the same time its social and spiritual implications are incomparably greater than any we have faced before.

Literally everything depends on correct and timely solutions to these problems. The present state of knowledge on the subject of atomic disintegration cannot justify specific predictions, but certainly we are entitled to guidance by the best views of those closest to the matter. The whole subject is so intimately tied up with military considerations and consequent secrecy, that details cannot now be revealed, but hints and bold speculations point to tremendous utility for atomic energy in the future. Therefore it is easy to justify efforts to gather and to summarize the best informed available opinion on the subject as it stands today for the readers of Scientific American.

EDITOR'S NOTE: After the article "Atomic Bomb" (page 238, October 1945 Scientific American) was prepared for publication, the now famous Smyth Report appeared. The accompanying article, based upon extensive correspondence with outstanding American physicists and upon the Smyth Report, complements our October article. Taken together, the two articles present the whole picture of the present status of atomic energy and the possibility of utilization of it in the future. Any further attempt at prophecy regarding atomic energy applications and their economics would be largely guess work.

In pursuance of this objective, the writer addressed a letter to 25 men of science, leaders in the development of the new weapon, asking three specific questions. The questions asked are given in the box on the following page.

Responses were generous and thoughtful. Above all they reflect the grave responsibility felt by each of the scientists as the custodian of an essential part of a secret of such overwhelming significance.

The protection placed around the development of the military weapon was complete in every respect. Secrecy surrounded not only results but every phase of the work. For more complete secrecy, the subject matter was subdivided into such small units that no one person and no small group ever knew, and does not yet know, of the whole matter. Furthermore, the intense preoccupation of each person engaged in the tremendous enterprise with his small segment of it precluded his interest beyond the narrow assigned area. Necessarily the details of a military weapon of such stupendous power as the atomic bomb will properly continue under strict secrecy. But the possibilities inherent in controlled atomic disintegration are so freighted with human destiny that they must be discussed and their implications must be understood by every thinking American. The matter must be freely discussed, debated, and pondered.

The implications of the military weapon are already sufficiently evident in the surrender of Japan. Preliminary reports of the terrible destruction of Hiroshima and Nagasaki will undoubtedly be much amplified before this article can appear in print. Clearly the facts, when fully known, will prove the strongest possible stimulus to peace.

Most responses to the writer's questions emphasized the necessity for continued observance of the secrecy imposed upon all connected with the project. These generally referred to what is commonly called the Smyth Report, an official document of 174 typewritten pages written by Dr. H. D. Smyth and entitled "A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government. 1940-1945."

This report, issued August 12 and subsequently published by the Princeton University Press, contains the scientific background of atomic disintegration as a source of power, the history of the project resulting in the atomic bomb, and such details of the whole matter as are proper to reveal at this time. Quite probably this will be the only publication regarding most aspects of the project. The Smyth Report contains a brief prophecy as its concluding paragraphs. These, in broad general terms, answer the questions asked of the 25 physicists and hence are quoted here:

"Prognostication

"13.4. As to the future, one may guess that technical developments will take place along two lines. From the military point of view it is

reasonably certain that there will be improvements both in the processes of producing fissionable material and in its use. It is conceivable that totally different methods may be discovered for converting matter into energy since it is to be remembered that the energy released in uranium fission corresponds to the utilization of only about one-tenth of one percent of its mass. Should a scheme be devised for converting to energy even as much as a few percent of the matter of some common material, civilization would have the means to commit suicide at will.

"13.5. The possible uses of nuclear energy are not all destructive, and the second direction in which technical development can be expected is along the paths of peace. In the fall of 1944 General Groves appointed a committee to look into these possibilities as well as those of military significance. This committee (Dr. R. C. Tolman, chairman; Rear Admiral E. W. Mills (USN) with Captain T. A. Solberg (USN) as deputy, Dr. W. K. Lewis, and Dr. H. D. Smyth) received a multitude of suggestions from men on the various projects, principally along the lines of nuclear energy for power and the use of radioactive by-products for scientific, medical, and industrial purposes. While there was general agreement that a great industry might eventually arise, comparable, perhaps, with the electronics industry, there was a disagreement as to how rapidly such an industry would grow; the consensus was that the growth would be slow over a period of many years. At least there is no immediate prospect of running cars with nuclear power or lighting houses with radioactive lamps although there is a good probability that nuclear power for special purposes could be developed within ten years and that plentiful supplies of radioactive materials can have a profound effect on scientific research and perhaps on the treatment of certain diseases in a similar period.

"Planning for the Future

"13.6. During the war the effort has been to achieve the maximum military results. It has been apparent for some time that some sort of government control and support in the field of nuclear energy must continue after the war. Many of the men associated with the project have recognized this fact and have come forward with various proposals, some of which were considered by the Tolman Committee, although it was only a temporary advisory committee reporting to General Groves. An interim committee at a high level is now engaged in formulating plans for a continuing organization. This committee is also discussing matters of general policy about which many of the more thoughtful men on the project have been deeply concerned since the work was begun and especially since success became more and more probable.

"The Questions before the People

"13.7. We find ourselves with an explosive which is far from completely perfected. Yet the future possibilities of such explosives are appalling, and their effects on future wars and international affairs are of fundamental importance. Here is a new tool for mankind, a tool of unimaginable destructive power. Its development raises many questions that must be answered in the near future.

BEFORE preparing the accompanying article, Mr. Killeffer, the author, asked the following questions of 25 physicists who had parts in the development of atomic bombs:

(1) Do you see a possibility within a reasonable time of the application of atomic energy on a reasonable scale to industrial purposes?

(2) What general forms do you anticipate applications of this kind are likely to take?

(3) Are you willing to hazard a guess as to the probable length of time that will be required from now on to develop any general usefulness for atomic energy?

How these men of science responded is told in these pages.

"13.8. Because of the restrictions of military security there has been no chance for the Congress or the people to debate such questions. They have been seriously considered by all concerned and vigorously debated among the scientists, and the conclusions reached have been passed along to the highest authorities. These questions are not technical questions; they are political and social questions, and the answers given to them may affect all mankind for generations. In thinking about them the men on the project have been thinking as citizens of the United States vitally interested in the welfare of the human race. It has been their duty and that of the high government officials who were informed to look beyond the limits of the present war and its weapons to the ultimate implications of these discoveries. This was a heavy responsibility. In a free country like ours, such questions should be debated by the people and decisions must be made by the people through their representatives. This is one reason for the release of this report. It is a semi-technical report which it is hoped men of science in this country can use to help their fellow citizens in reaching wise decisions. The people of the country must be informed if they are to discharge their responsibilities wisely."

THE ESSENCE—That represents the essence of the thought of the principal workers on the project. It remains merely to add to this general view a brief summary of the specific thoughts supplied by those queried.

Emphasis is universally placed on the restricted view of each person engaged on the project. Even those who occupied key positions found their interests, activities, and information confined within limited areas. Thus it has so far been impossible for anyone to view the whole problem in proper perspective, and consequently a considered opinion of future possibilities is virtually impossible to form under the circumstances.

The view is expressed that present use of atomic energy in a destructive bomb is in no sure sense a guarantee that this type of power will be usable in other ways. A great deal remains to be done before an operable method of utilizing energy of such enormous concentration can be devised. When an operating device is reached there will still remain vital problems of efficiency and cost as compared with other power sources to be solved. Involved in all this will undoubtedly be many basic inventions. These may be made at any time and such is the intensity and pace of present-day research that the most important of these can scarcely be delayed more than a very few years (say 5 or 10).

On the basis of the meager information now available to anyone on the entire subject, it seems futile to attempt any estimate of the engineering phases of power development. The high penetration and extraordinary power of the radiation emitted by present nuclear reactors requires such heavy shielding as to preclude their use in any presently practicable vehicle with the possible exception of large steamships.

While this aspect of present reactors keeps them out of vehicles and limits their possibilities in stationary units, it is clear that even present rudimentary techniques provide a source of practically boundless supplies of radioactive materials for medical and industrial purposes. Many of these applications are yet wholly unexplored, such possibilities having been neglected in the

past in view of the extreme scarcity and high prices of radium.

Finally, one must realize that the whole matter of power from this new source is and undoubtedly will remain for a considerable time in a state of flux. Its interrelations with the military applications are too close to permit open discussion of all details soon. Yet the whole problem is substantially closer to solution that it was even months ago. We can look forward to a better day for all men to come from this development within, let us say, a decade or two—certainly well within the lifetimes of many now living.

RAT KILLER

Does not Affect Acceptability of Bait

SODIUM FLUOR-ACETATE, a new synthetic compound, has shown great promise as a poison for mice, rats, prairie dogs, ground squirrels, and other small mammals that constitute serious pests. The high toxicity of the compound, known as "1080," allows it to be administered in poisoned baits and food without seriously affecting the acceptability of the food for the pests. The compound is also intensely poisonous for man and other animals and must be used under the most carefully controlled conditions.

FUNGI

Found Readily by Use of Ultra-Violet Light

DETECTION of fungi and location of infected areas are necessary in cleaning up valuable equipment and instruments returned for repair or salvage from tropical war areas. In normal light fungi are difficult to see except in lush growth, but ultra-violet light immediately reveals their presence by causing the organisms to glow by natural fluorescence. Clearly outlined in this manner, eradication of the fungi is much simplified.

PENICILLIN PRODUCTION

Involves Large Usage Of Banana Oil

ALTHOUGH the 400 billion units of penicillin now being produced monthly weigh only some 530 pounds, the amount of material that must be processed in production sometimes is so great as to be critical. Recent reports suggest that 85 to 90 percent of the nation's amyl acetate ("banana oil"), important as a solvent, is consumed in this production. That proportion is too great for the comfort of other industries needing this solvent and hence steps are being taken to develop efficient processes for its recovery.

TORPEDO RECOVERY

Made More Certain by Synthetic Resin

A WATER-SOLUBLE synthetic resin disk placed in a naval torpedo dissolves when the torpedo is lost and releases a float that enables searchers to find it. The resin used is one of a family that can be prepared from polyvinyl alcohol. These resins can be given any desired degree of solubility in water, from complete insolubility to easy solution. The safety disk is designed to dissolve in a predetermined time, long enough to allow the torpedo to be completely tested, but short enough to expedite searches for any that escape and sink.

DDT TROUBLES

May Hinder Use of its Valuable Properties

RELEASE of DDT to civilians for general use recently, led to a flood of preparations presumably containing this highly effective insecticide but actually too dilute to be useful. Warnings promptly issued pointed out that abuse of the compound in this way by unscrupulous persons is likely to lead users to conclude that DDT has no value, when as a matter of fact it is highly effective when properly used.

Legitimate insecticide producers are proceeding cautiously to be sure that any preparations they offer are effective and that correct instructions for their use are also provided. DDT itself (dichloro-diphenyl-trichloroethane) requires to be compounded with other materials to be fully effective and at the same time safe for use. Some additives, notably solvents, increase the toxicity of DDT for human beings unduly and thus introduce excessive hazards into its use. Fear is expressed that unfortunate experiences with early improper DDT preparations may prevent its legitimate later use for valuable purposes.

SPECIFIC GRAVITY

Quickly Determined by Vacuum Method

A NEWLY devised and rapid method of determining the specific gravity of an unknown liquid consists in comparing the height to which it will rise in a tube with the rise of a known liquid in a tube under equal vacuum. In practice, the unknown and the standard liquids are drawn up into two parallel glass tubes joined at the top and connected to suction at the junction point. The heights of the columns in the two tubes are in inverse ratio to the specific gravities of the two samples. Accuracy can be increased by calculating from measurements of differences in the height of the columns under two different suctions. The specific gravity, accurate to the fourth decimal place, can be quickly determined in this way.

PENICILLIN

When Properly Protected Can Be Taken by Mouth

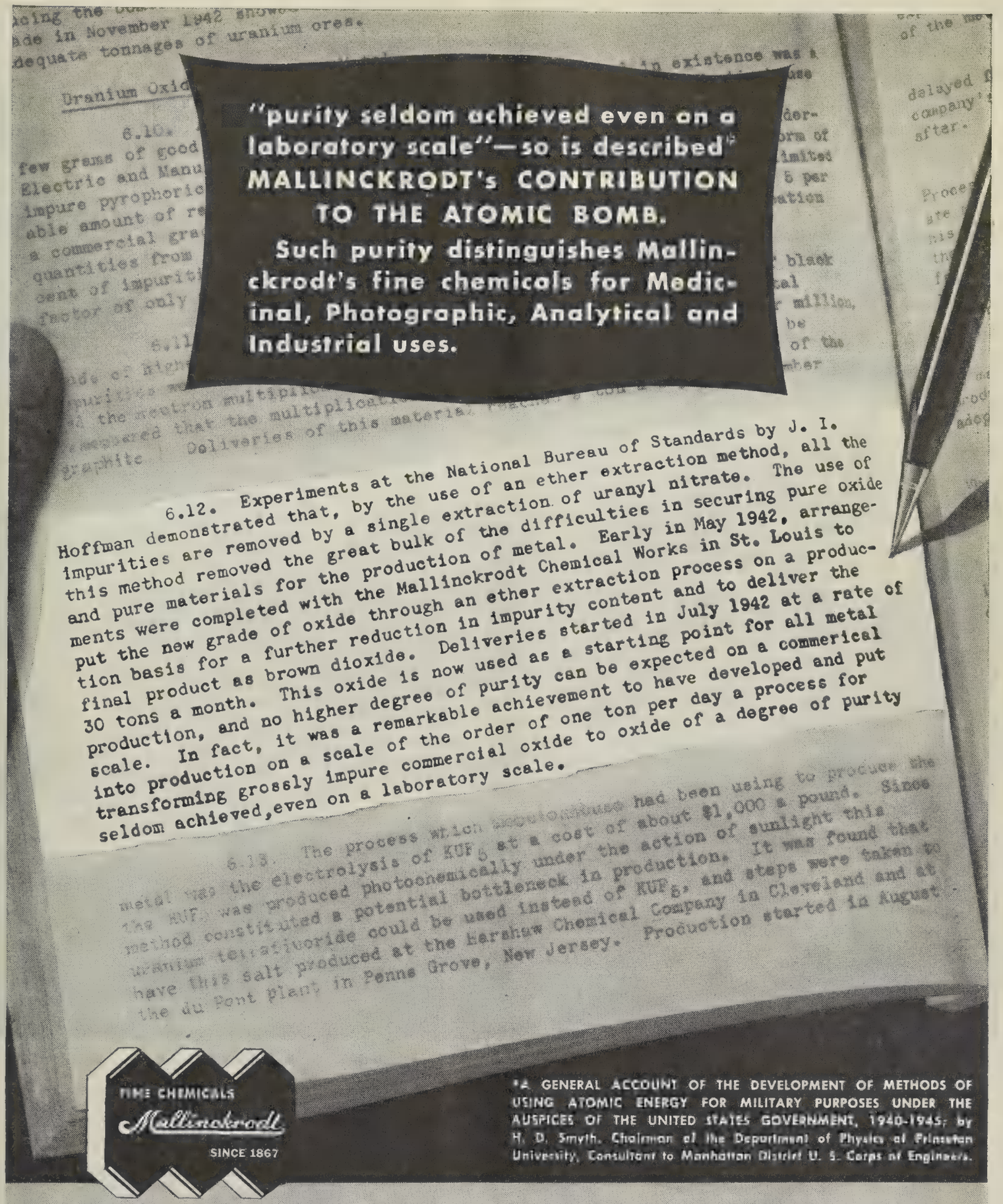
EFFORTS to find a way to administer penicillin effectively without the use of a hypodermic syringe have developed various methods designed to protect the active principle of the drug while it is passed through the stomach when taken by mouth. Apparently absorption of penicillin takes place from the small intestine, but the drug is delicate and cannot survive the high acidity of the human stomach. Several suggestions have been based on the inclusion of various anti-acids with the penicillin in the dose but it has been found that high alkalinity also destroys its effectiveness. One successful method dissolves the drug in oil. Latest successes have been scored by the use of calcium carbonate—precipitated chalk—to neutralize stomach acidity without creating alkalinity since the neutralizing agent is insoluble except in acid.

SAFER LABELING

Important in Handling Of Hazardous Chemicals

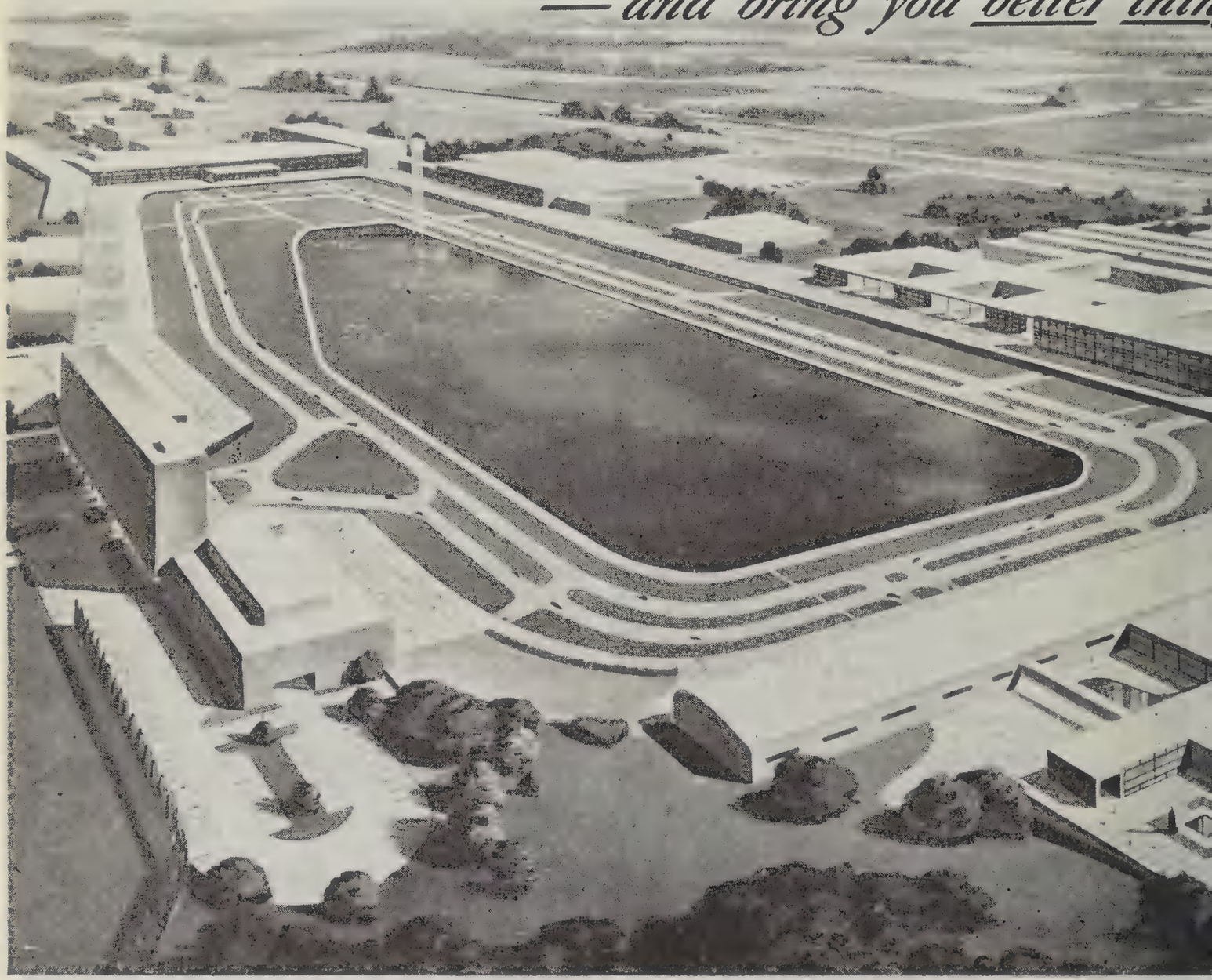
THE FIRST comprehensive effort to systematize and standardize labeling of hazardous chemicals, considered of special importance in view of the pace of developments in the industry, has just been completed and published by the Manufacturing Chemists' Association of the United States.

The main objective of the work is to discourage use of code labels which leave the user with no information about the product. Principles are established to govern preparation of precautionary labels, with maximum emphasis on protecting the users, handlers, repackers, jobbers, and distributors of chemical products or others who may be less familiar with them than the manufacturers.


"purity seldom achieved even on a laboratory scale"—so is described*
MALLINCKRODT's CONTRIBUTION TO THE ATOMIC BOMB.
Such purity distinguishes Mallinckrodt's fine chemicals for Medicinal, Photographic, Analytical and Industrial uses.
6.12. Experiments at the National Bureau of Standards by J. I. Hoffman demonstrated that, by the use of an ether extraction method, all the impurities are removed by a single extraction of uranyl nitrate. The use of this method removed the great bulk of the difficulties in securing pure oxide and pure materials for the production of metal. Early in May 1942, arrangements were completed with the Mallinckrodt Chemical Works in St. Louis to put the new grade of oxide through an ether extraction process on a production basis for a further reduction in impurity content and to deliver the final product as brown dioxide. Deliveries started in July 1942 at a rate of 30 tons a month. This oxide is now used as a starting point for all metal production, and no higher degree of purity can be expected on a commerical scale. In fact, it was a remarkable achievement to have developed and put into production on a scale of the order of one ton per day a process for transforming grossly impure commercial oxide to oxide of a degree of purity seldom achieved, even on a laboratory scale.
*A GENERAL ACCOUNT OF THE DEVELOPMENT OF METHODS OF USING ATOMIC ENERGY FOR MILITARY PURPOSES UNDER THE AUSPICES OF THE UNITED STATES GOVERNMENT, 1940-1945; by H. D. Smyth, Chairman of the Department of Physics at Princeton University, Consultant to Manhattan District U. S. Corps of Engineers.
FINE CHEMICALS
Mallinckrodt
SINCE 1867
MALLINCKRODT CHEMICAL WORKS
78 Years of Service to Chemical Users
Mallinckrodt St., St. Louis 7, Mo. · 72 Gold St., New York 8, N.Y.
CHICAGO · PHILADELPHIA · LOS ANGELES · MONTREAL

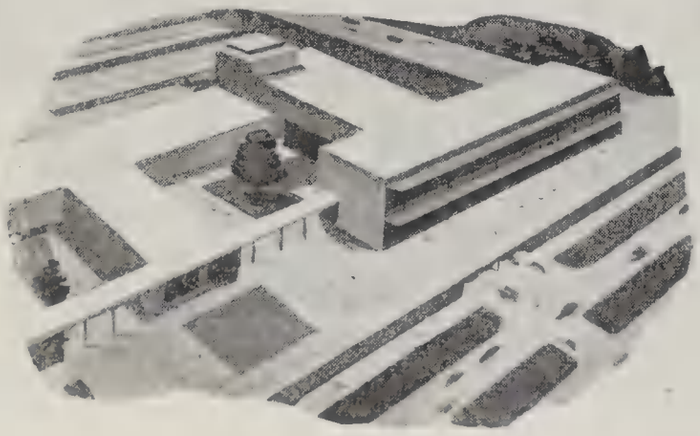
TO SPEED THE PACE O

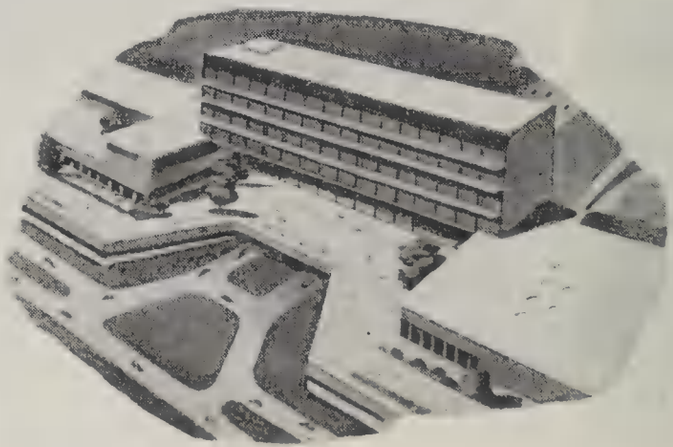
— *and bring you better thin*



THE BUILDINGS of the Technical Center will face a seven-acre lake. These buildings will be connected by a covered walk and vehicular roadway. Sketched below is the Advanced Engineering Building in which improvements will be quickly made in existing products.

LOCATED ON a major highway leading from Detroit, access to the Center will be through the Administration Building sketched here. A system of modern roadways will provide practical opportunity to study traffic control as well as to make simple road tests of new car developments.



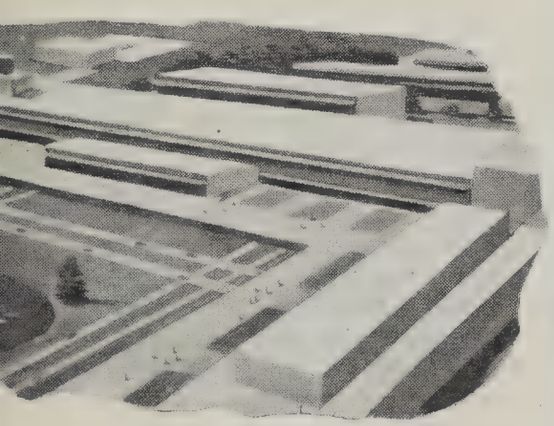


PROGRESS

more quickly



A FLOOD OF SUNSHINE will pour into the southern windows of the Research Buildings where experimental work is carried on in such diverse fields as the study of chlorophyl, research into fuels and engine design.



The New GENERAL MOTORS TECHNICAL CENTER will be created to stimulate opportunities, promote employment and bring about MORE and BETTER THINGS FOR MORE PEOPLE

THESE are times when the world cries out for new and finer things. There is a great hunger, broad as all mankind, for happier relationships among men — for greater individual opportunity for accomplishment, for more and better goods within reach of everyone.

It is by satisfying this hunger that we can bring greatest benefit to our national economy in the future. Through such action lies the road to more good jobs, to an ever-rising standard of living through the continual replacement of old things with new and better ones.

The General Motors Technical Center is dedicated to such an objective. It will occupy a 350-acre tract of land outside of Detroit as soon as conditions permit. Its purpose is to develop new things that add to the comfort and security of our living, and to enable existing things to be made more efficiently, hence at lower selling prices, so more people may own and enjoy them — all with expanding job opportunities.

It will shorten the time required to bring the work of creative thinkers out of the idea stage and into usable reality.

Here in groups of buildings designed especially for the purpose, General Motors will gather in advantageous and inspiring new surroundings the most modern facilities for research, advanced engineering, styling and the development of new manufacturing techniques.

Here physicists and engineers will discover new facts and convert them into new improved products. Stylists will give them new and more attractive form. Process engineers will develop better manufacturing techniques for making them.

Science here will go to work in the interest of economic progress. And history is full of proof that when science is so harnessed, more jobs are created, more comforts and conveniences are brought within reach of more people.

Serving as a source on which the engineering staffs of all of our Divisions may draw, the General Motors Technical Center will stimulate improvement in all General Motors products. Automobiles, refrigerators, Diesel engines, locomotives and other good and useful things may be expected to be improved at even faster pace than in the past.

But the work of the Technical Center will not be confined to existing things. It is dedicated to the idea that progress is the servant of mankind and that whosoever advances it not only helps himself but his fellow men. Its goal will be "more and better things for more people," whether that comes through improvement of the old or development of the new.

GENERAL MOTORS

MORE AND BETTER THINGS FOR MORE PEOPLE

CHEVROLET • PONTIAC • OLDSMOBILE • BUICK • CADILLAC • BODY BY FISHER
FRIGIDAIRE • GMC TRUCK AND COACH • GM DIESEL

Every Sunday Afternoon
GENERAL MOTORS SYMPHONY OF THE AIR—NBC Network

MAKE VICTORY COMPLETE—BUY MORE WAR BONDS

Lithium, Servant Metal

As a Scavenging Agent, This Lightest of All Metals Makes Possible Alloy Castings that are Stronger, Less Porous, and Higher in Electrical Conductivity. Because of its Extreme Chemical Activity it Purifies Alloys and Gives Them Much Finer Grain Structure

NATURE seems to have given the United States another world-wide superiority in a resource to join those of iron, petroleum, and so on. This latest one is lithium. The best source of lithium is Searles Lake, at San Bernadino, California. Searles Lake is a dry lake in which the evaporating water left all kinds of valuable salts which are processed by heavy chemical industries. One of the by-products of processing contains over 10 percent of lithium as compared to a top of 3.3 percent in spodumene, the most used ore.

There is plenty of spodumene, too, in the Carolinas and in the Rockies. The trouble is, it has never been possible to get the price of lithium extracted from this and other ores down below the present level of from $12.50 to $20.00 a pound, nor is the Searles Lake concentrate any better in this respect so far. But with the uses of lithium advancing rapidly and with the bright promises of the Searles Lake development, the price might get down to $5.00 a pound. And that would make big differences to many an industry. Lithium is making big differences even at its present price.

Lithium is a strange metal. It is the lightest of metals—a cubic foot of it weighs only 33 pounds *vs* 108 pounds for the same amount of magnesium and 176 pounds for aluminum—and yet it very seldom will be used as a light-weight structural metal itself nor to lighten the weights of other alloys. It can be purified to a commercial degree very easily, yet it seldom will be used in pure form. It can be alloyed very easily with other metals, yet only a fraction of its total production will be used as a constituent of alloys. It already is an important metal of industry and is destined to be a far more important one, yet in its largest commercial applications it does not gain its markets by displacing other products.

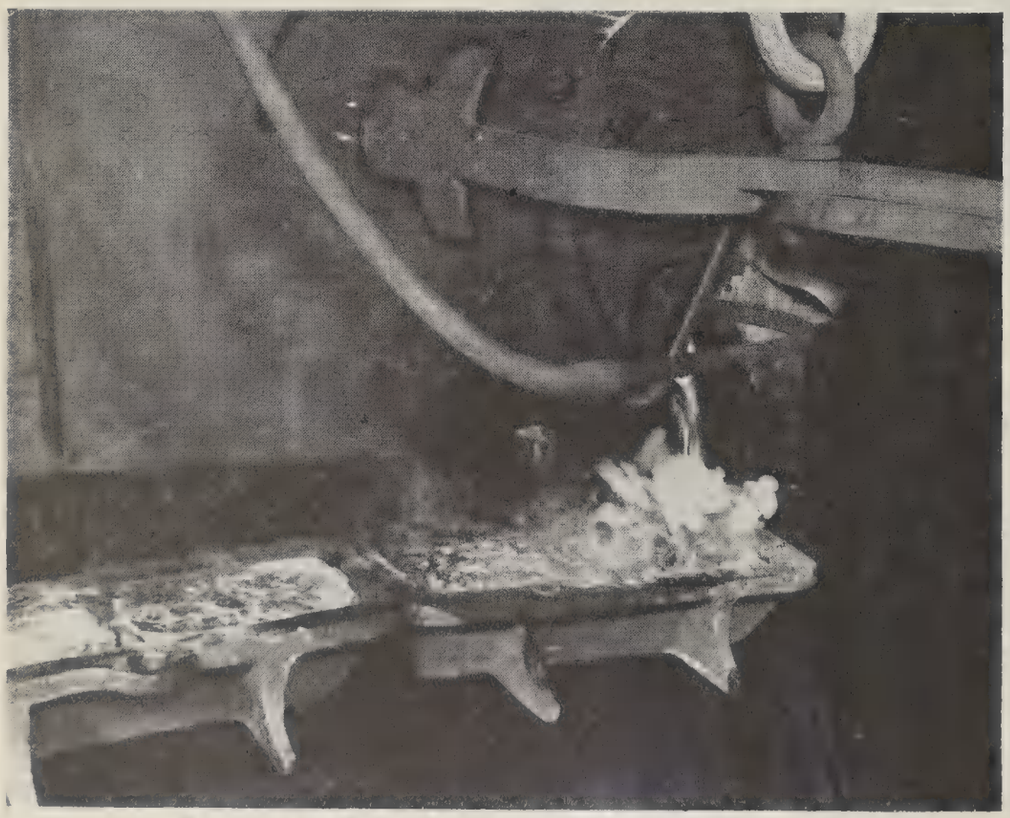
The reason for these seeming contradictions is simple. Lithium is a "servant" metal. Its big function in metallurgy is to help other metals to behave better. It does the same thing for gases, welding-rod fluxes, lubricants, soaps, and air conditioning.

IMPORTANT TASK—One major use of lithium is in the making of nonferrous alloy castings. Only about 0.01 percent of lithium is used in the ordinary metallic mixture, and only about 0.05 percent is, in most cases, found in the finished casting. Sometimes only a trace of lithium remains. And yet the task of the lithium in the making of the casting is an important one.

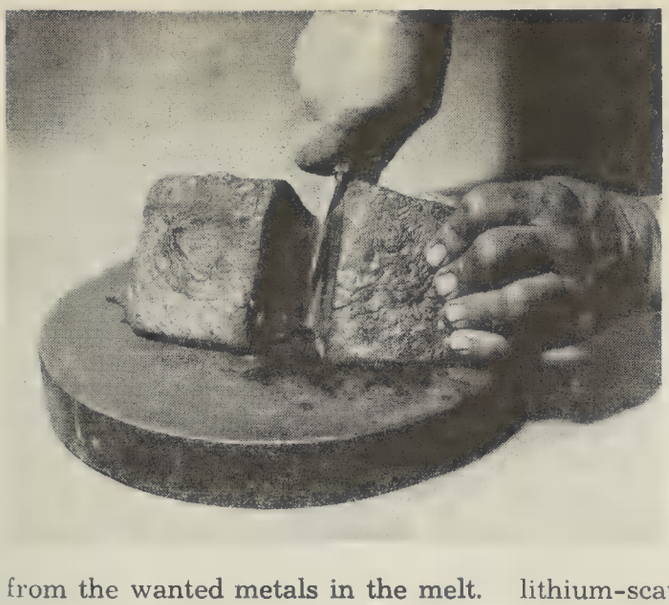
Nonferrous alloy castings are made of metals (copper, zinc, and so on) which have different melting points. They also solidify at different temperatures when being individually cooled. Melted and cooled together, as they must be for casting, they have all sorts of behaviors toward each other. They form solutions, emulsions, matrixes. They combine in varying grain sizes and shapes.

While all of this is going on, various "unwanted" elements also are at work within the melt. Gases and impurities like hydrogen, oxygen, nitrogen, sulfur, and particles of sand, are having bad influences on the ways in which the "wanted" elements are behaving toward each other. The unwanted elements are changing the grain structure for the worse, causing porosity and setting up weak spots.

Here is where the lithium goes to work. Lithium is the most chemically active of all the metals. It combines with almost any gas, taking that gas unto itself and away



Pouring molten lithium from an electric furnace into ingot molds



Lithium is so soft that it can easily be cut with an ordinary pocket-knife

from the wanted metals in the melt. It takes hold of sand particles, too, and of other impurities. Opposite to the corruption resisting "noble" metals like gold and platinum, lithium welcomes corruption.

Now the extremely light weight of lithium comes into play. It rises to the surface of the liquid, molten metal, bringing the impurities with it. Behind is left a melt of cleaner, purer metals.

The grain structure of the lithium-scavenged casting is likely to be much finer, as much as 98 percent finer in some cases. Gas pockets, "blow holes," and porosity can be completely eliminated.

The real story is summed up in the metallurgist's expression: "theoretical maximum values." For every alloy which is cast there is a list of such values in tensile strength, electrical conductivity, coefficient of friction, and others. If a melt is mixed and cast perfectly it can reach those values—be at the best which is theoretically possible for it. If handled perfectly it will have lower values or abilities in various respects. And lithium-scavenged castings are likely to approximate many of their theoretical maximum values.

Electrical conductivity is an example. Lithium-scavenged castings often reach their maximum conductivities at normal temperatures. Thus their desirabilities for electrical purposes are greatly increased.

GREATEST STRENGTH—Most important of all, the castings can approximate their theoretically greatest strengths. This is partly a matter of uniformity, of being sure that all parts of the casting are more nearly alike and that the whole casting is more dependable. Outright additions of strength as compared to ordinary castings can be had too. A maker of Navy composition "G" castings found that before lithium was used the tensile strength was 42,000 pounds per square inch; lithium-scavenging raised it to a range of 48,000 to 52,000. Similarly, the elongation was raised from about 35 percent to a range of 45 to 65 percent. With every equipment maker trying to work with more and more power at higher and higher speeds while fitting his machine parts into smaller and smaller spaces, increased strength with increased uniformity means that lithium-treated castings may be used for many purposes from which the same alloys might otherwise be excluded.

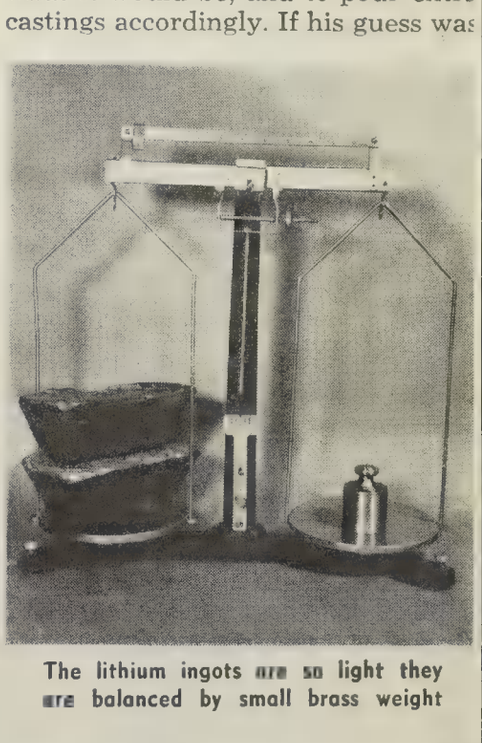
Pure lithium is not likely to be used in any foundry. It is added to copper and brass products in electrical furnaces in copper and brass mills, but for most foundrymen it would be bothersome to handle.

Rather, "master alloys" containing varying proportions (usually from 2 to 10 percent) of lithium are purchased from such companies as the Lithaloys Corporation. The balance of these alloys is copper, zinc, or some of the other "wanted" metals of the castings. These "balance metals" enter directly into the castings, and if the mix is to be carefully controlled then their amounts are considered in proportioning it.

The amount of lithium in a master alloy depends first upon the scavenging to be done—there must be enough for this—and second upon the degree of grain refinement needed for the purpose of the casting. The more the lithium the finer the grain. Very seldom is more than 1 pound of master alloy added to each 100 pounds of melt, and almost never more than 1½ pounds. These points require careful metallurgical consideration for which the master alloy maker supplies a consulting service.

In the foundry, the master alloy must be added early enough, usually from three to five minutes before the mix is poured, so that the lithium will have enough time to do all of its work. And the stirring-in must be so controlled as to do a thorough job without unduly disturbing the mix.

Castings made by these methods are likely to approach the "no spoilage or rejections" ideal of mass production. One foundryman averaged 25 percent of weepers (castings rejected for porosity) before using lithium-scavenging—less than 1 percent afterwards. When spoilage ran so high he always had to guess what it would be, and to pour extra castings accordingly. If his guess was



The lithium ingots are so light they are balanced by small brass weight

wrong—as it nearly always was—then he either had extra castings or else too few to fill his orders. With spoilage nearly eliminated he avoided this extra cost. Lithium-scavenging often saves its cost by the reduction of the percentage of rejections.

Fine grained, highly uniform castings work better on the lathe and milling machine than do their coarser grained brothers. Accuracies, surfaces, and finishes are better. This makes for better products at lower machining costs.

FOR STEEL, TOO—Lithium soon may do as much for the ferrous as for the nonferrous industries. Important studies are now being concluded and their results may be announced any day. When this news breaks, every steel mill producing every kind of steel from plain carbon to stainless and other high alloys, may be offered brand new advantages.

The bearings industry, also, is being helped by lithium. Many of the toughest bearings problems are in the mixing of lead-copper alloys for heavy-duty, heavy-pressure high-speed bearings such as are used in modern engines and other machines. The lead has the anti-friction qualities and the copper the compressive strength needed by

these bearings. But the trouble has been that some of the most desirable proportions of these two metals either could not be cast together at all or else they would form stratified grain structures which are too weak for this purpose. With tiny amounts of lithium in the mix some of these mixtures can be cast with complete success. The lithium takes care of the troubles which had previously caused the separation of the copper and lead.

Sometimes, lithium requires new industrial techniques. The die casting of zinc metals is an example. If lithium is alloyed with the zinc and the melt is kept in special types of closed melting pots and is fed under controlled atmospheric conditions such as are used in heat-treating furnaces (these methods will be brand new to many a die caster) then the alloys will flow with enough extra freedom to provide new opportunities to the die casting art.

Alloyed with magnesium—another of the up-and-coming "new" metals—lithium adds to tensile strength and hardness. And there are other lithium alloys as well which will be found in industrial products of the near future.

One odd use of lithium is in the production of hydrogen. A little less than five pounds of lithium hydride immersed in water will release 225 cubic feet of this gas. Our military forces used this process. Hydrogen from a small container of lithium hydride immersed in the ocean inflated a rubber balloon, the balloon raised one end of a copper wire 300 feet into the air, and the wire became the antenna by means of which the shipwrecked aviator or sailor radioed his call for help.

The figures on such hydrogen production are intriguing. Each pound of lithium hydride will yield a by-product of about three pounds of lithium hydroxide which is worth about $2.00 a pound today. With lithium hydride costing $12.50 a pound, even with the value of the by-product counted in, the hydrogen from it would cost about $15.00 a hundred cubic feet as compared to less than $2.00 (all factors considered) for hydrogen which is bought in rental-return steel containers. But if the price of lithium were to come down to its hoped-for $5.00 a pound then the cost of hydrogen from its hydride could become less than that of hydrogen in steel containers—the fact that the by-product hydroxide also might have less value being given full consideration. And even now, wherever the cost of transporting and handling the 140 pound steel cylinder is high enough to overbalance the price differential, hydrogen from lithium hydride will find a market.

In lubricants lithium both increases and decreases the temperature limits at which it is possible to use bearings. Although not an application of lithium in the metallic form, the use of lithium compounds in the production of atmospheres for metal-heating is receiving increasing attention. In industry after industry lithium pushes back other limitations. Lithium is a metal on the march. It is a valuable servant of industry and will become a more valuable one.



PUMPING MAGNESIUM

Molten Metal Can be Handled Economically by Pumps

TEN years ago the pumping of a molten metal was generally considered impossible, but today molten magnesium is being pumped in melt-shops and foundries with mass-production benefits not previously attainable.

Ordinary cast iron and steel pumps are used for magnesium, which melts as low as 1200 degrees, Fahrenheit, whereas special refractory equipment must be used for other higher melting point metals. According to Dow Chemical Company, molten magnesium is being pumped over distances from a few inches to 25 feet and in capacities from a trickle to a ton per minute.

With the use of pumping equipment, one operator can empty a 4000-pound pot of molten magnesium alloy into ingot molds in 30 minutes, or at the rate of one ingot every 12 seconds. Formerly two men, dipping metal from the pot and pouring it into each ingot mold, could empty one 2000-pound pot in about an hour—an efficiency improvement of about eight times on a man-hour basis.

ALLOY STEELS

Will Find Greater Use in the Future

THE FUTURE of alloy steels in this post-war era, the types of steels that will be used, and the relative importance of the electric furnace and the open-hearth furnace for their production are questions of great interest to the steel-producing and steel-using industries. The following forecast, based on the answers to a survey conducted by Edwin F. Cone, of *Metals and Alloys,* can now be made:

The post-war volume of alloy steels will be higher than pre-war and may even exceed the war-time level. A chief reason for this will be many new uses for alloy and stainless steels, especially in gas turbines, superchargers, jet-propelled planes, railway and automotive equipment, and so on. Most of the "lean" N.E. alloy steels will be discarded in favor of the older higher alloy types, but some N.E. steels will remain.

Post-war use of electric furnace steel will represent a greater percentage of alloy steel than pre-war, and consumers strongly believe the extra price charged for electric furnace grades over open-hearth alloy steel is warranted by the quality and uniformity advantages of electric steel. Steel producers do not expect to be able to lower the selling prices of electric furnace steels, although some large electric furnaces can approach the open hearth in their economics.

STEEL RECONVERSION

Costs Will Include Repair of Worn Facilities

TO RECONVERT plants and equipment to handle the expected production of steel for non-military and civilian use, steel companies are planning to spend more than $200,000,000. Reported costs of reconverting steel plants do not include any expenditures which individual steel companies may be planning.

Part of the $200,000,000 will be spent for reconverting to peace-time production the big continuous wide-sheet mills, which during the war were adapted to permit the rolling of large tonnages of heavy plates for shipbuilding and so on. Other reconversion tasks facing the industry include realinement of steel fabricating departments and plants from production of such war goods as deck houses for merchant ships, artillery shells, and tank armor to production of commercial products.

Large expenditures will be required for the repair of facilities which have become badly worn under the strain of operations during the war. Heating facilities of all descriptions are reported to be particularly in need of attention. Because furnaces are difficult to repair quickly, patching jobs have been resorted to frequently during the war emergency period by some steel companies to save time.

The estimated cost of reconverting the steel industry is less than 10 percent of the total amount of money spent since 1940 by the steel industry and the government to expand and supplement steel plants and properties for war-time production.

Is there a way to get 4 times the service from things made of steel?

THE ANSWER to this question may soon affect your life . . . *and* your pocketbook . . . in a big way. Because there is a remarkable discovery that will enable you to get up to *4 times the service* for every dollar spent on items made of steel! From washing machines, automobiles, hardware, tools, wire fencing, screens—dozens of products whose life was formerly cut short by rust.

This remarkable discovery is CORRONIZING, a new patented process of plating steel with a tissue-thin "armor" that *far outlasts other rust-protection coatings.*

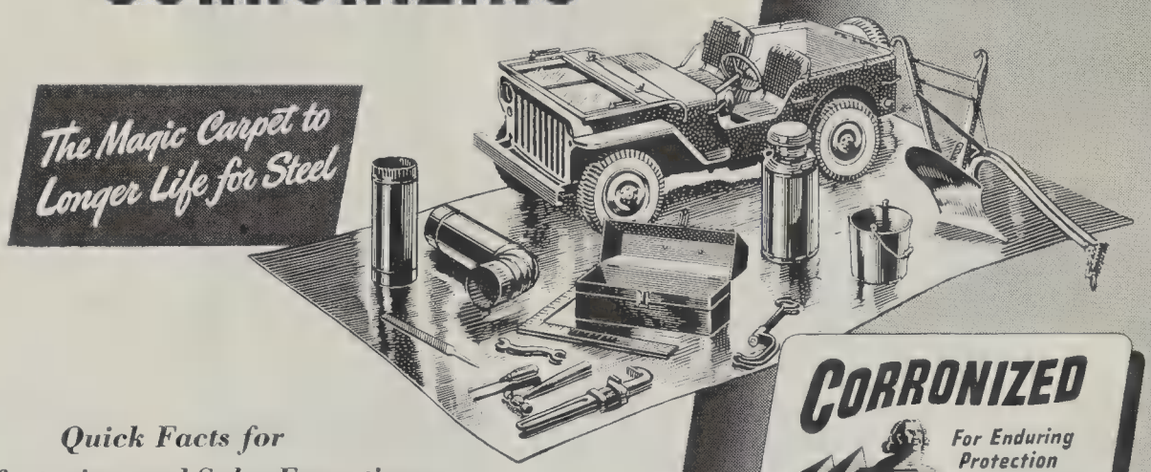
Actual use in the war, in every kind of climate, gives proof to that statement. Now, America's more progressive manufacturers and retailers will be able to bring you many articles with the sensational advantages of "Corronized" steel. New model automobiles, always famous for progress, will be among the first to bring you these advantages.

So, if you want utmost dependability, lasting beauty and safety in things made of steel, wisely inquire whether they are made of "Corronized" steel. If they are, you'll be the winner in years of service . . . *by as much as 4 to 1!*

Standard Steel Spring Co.

ORIGINATORS OF

CORRONIZING



CORRONIZED
For Enduring Protection
Against Rust

Quick Facts for Manufacturing and Sales Executives

Do not confuse CORRONIZING with other metal coatings. This patented process provides a permanent alloy "armor" with 5 layers of defense against corrosion! It becomes part of the steel base . . . can be worked in any manner. Permits using lighter materials by prolonging steel's period of greatest strength. Write for samples and complete information.

STANDARD STEEL SPRING COMPANY
CORAOPOLIS, PENNSYLVANIA

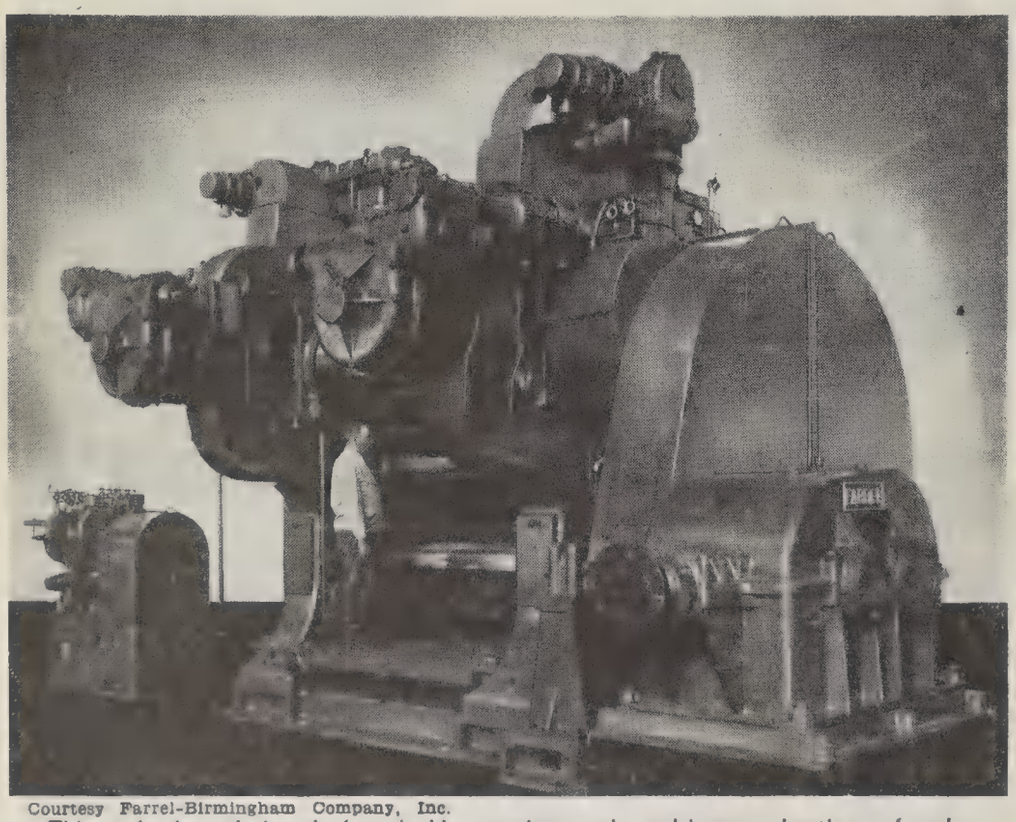
Petroleum In Plastics Processing

Hydraulic Presses, Operating Around the Clock, Must Use the Correct Fluid for Continued Economical Operation. Heat Transfer, Rust Prevention, and Adequate Lubrication are Other Special Problems of the Plastics Industry that are Being Solved by Petroleum Products

MENTION of petroleum in the plastics industry immediately brings to mind the various synthetic compounds which have petroleum as one of their basic ingredients. But petroleum has another and equally important role in the industry. As lubricants, hydraulic fluids, and heat exchange mediums, petroleum products are used in all types of plastics processing equipment.

In the machinery used in the production of such basic materials as esters and monomeric hydrocarbons, petroleum has been instrumental during the past four years in keeping the mechanical equipment necessary to the production of plastics articles in running order. And this in the face of day and night operating schedules which taxed the newest equipment as well as the over-age machines that had to be kept running for want of replacements.

Now, as plastics processors turn to peace-time civilian and industrial articles, there is no abatement in the importance of using the right petroleum product in the right place. To meet the anticipated demand, plastics machinery must continue to operate on a rapid, accurate, full-time basis. And machinery which is running at repair or maintenance cycles because operators are ignorant of the newer and more suitable petroleum products, can seriously retard the flow of plastics articles to the civilian market—and add considerably to their cost because of low production and expensive machine repairs resulting from incorrect lubrication.



Courtesy Farrel-Birmingham Company, Inc.
This calender, designed for double coating and multi-pass sheeting of rubber and plastics, uses special oil and grease in operation of its heavy rollers

It should not be thought, however, that petroleum products are cure-alls, that the use of the correct oil at the correct spot will prevent all mechanical difficulties. But just as bad is the belief that any quality of oil will be satisfactory for all classes of service.

The truth lies somewhere between these extremes. Petroleum products are, rather, preventive maintenance materials that greatly influence continuity of equipment service and, to an important degree, overall operating costs. In the following list are presented some of the factors that are influenced or controlled entirely by lubrication in modern machinery:

1. Machine down-time and labor for cleaning oil systems.
2. Lubricating oil cleaning (filtering, filter material replacement, centrifuging, and so on).
3. Oil consumption or make-up.
4. Machine parts failure and replacement costs.
5. Power costs.
6. Costs of lubricants and their application.

How well-informed use of petroleum products can thus affect the operation of plastics production equipment will become evident as the various uses are discussed in some detail.

HYDRAULIC PRESSES—The most widely used machine tools in the plastics industry, hydraulically operated presses cover the entire range of compression, transfer and injection molding, and extrusion. For these methods of processing, smooth functioning of the moving parts is all-essential. This means that there must be no sticking of the pistons, no leaking valve, no worn pump parts. Also, the fluid must not deteriorate and foul the pump and the control mechanism.

One of the prinicipal causes of pump wear in hydraulic presses,

particularly in vertical units operating in the plastics industry, is the abrasive ferrous oxide formed on the interior of the reservoirs which combines with microscopic particles of plastics dust blown from the mold platens at the end of each operation. Adhering to the oil wetted plunger, these dust particles are gradually drawn through the packing gland into the oil system.

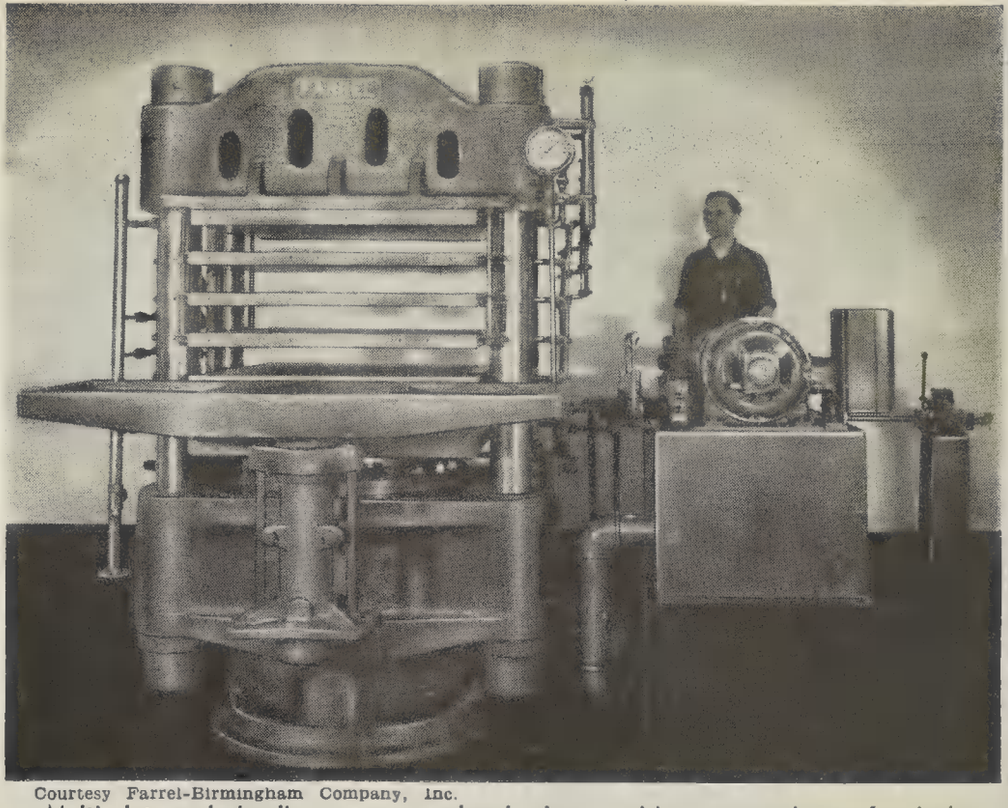
A further source of contaminants that accelerate pump wear is found in the metallic soaps which may be formed in the deterioration of petroleum. These soaps form sludges which are picked up from the bottom of the reservoir and circulated throughout the entire system. When these sludge formations become aggravated they deposit on the metal surfaces and, at times, varnish hydraulic plungers to a point where the presses operate erratically and tear the packing gland from its seating.

Where water collects in the hydraulic system the problem of pump and plunger wear is further aggravated. This is because many oil decomposition products are water-soluble organic acids and tend to attack the metal surfaces of the hydraulic system, often etching them quite badly. This etching action also releases finely divided metal particles into the system where they act as an abrasive, grinding away machined surfaces.

Some of the older press installations employ water alone as the hydraulic fluid. This type of fluid, however, is not as economical as it would at first appear, due to the cost of periodically replacing packings and refinishing control valves and plungers. One solution is the addition of wetting agents and soluble oils to the water—a blend of one part soluble oil to 60 parts water. A reduction in corrosion within the fluid system is an immediate result of this addition, a circumstance which exerts a protective influence on the control mechanism. But to maintain the fluid stream in a physically clean condition by reducing the concentration of solids to the lowest possible degree, inexpensive mechanical filtering devices are required.

Oil is the best hydraulic fluid for modern presses which usually are equipped with individual reservoirs, pumps, and control mechanisms. To assure continuous service of this equipment, oxidation resistant hydraulic oils containing corrosion preventives are often used since these oils lessen oil and machine maintenance and do not precipitate deterioration products.

Sometimes, however, corrosion occurs independently of the oil in the system. For example, the underside of the top of the oil reservoir may corrode to a point where rust drops into the oil and contaminates the oil stream. This danger can be eliminated through the use of an oil- and water-impervious coating on the inside of the reservoir.



Courtesy Farrel-Birmingham Company, Inc.

Multi-platen hydraulic press employed in precision processing of single sheets or laminates uses oil in the cylinders for the operation of the rams

Foaming of hydraulic-press oils, however, *is* dependent upon oil quality and its resistance to deterioration. The entraining of small air bubbles, which is common in hydraulic oils that contain even small amounts of acidic and saponifiable material, will reduce pump capacity and produce erratic plunger operation. The more thoroughly refined oils will reduce these troubles since they contain fewer oil decomposition products and hence have less tendency to hold moisture and finely divided air in suspension.

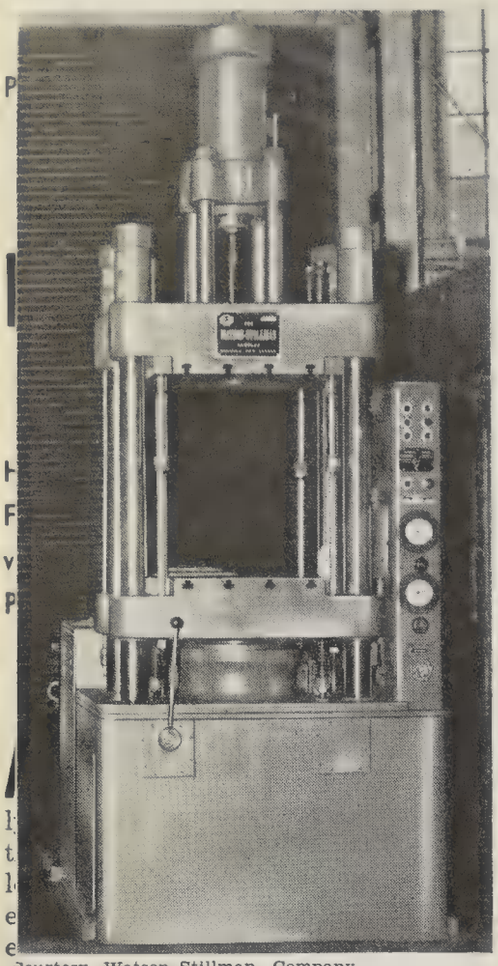
That the use of oxidation-stable hydraulic oils is economical as well as good operating practice is evident from the fact that these oils almost completely eliminate control mechanism wear. Since the lubricant does not tend to deteriorate in service, waxy or varnish-like substances are not deposited on the plungers and controls; therefore oil leaks through packing glands are reduced and the life of the packing is greatly extended.

A further economy is achieved by periodically filtering the oil in each hydraulic system without removing the press from service. Much less labor and expense is involved than when efforts are made to salvage deteriorated hydraulic oils in an independent recovery system. And this filtration will also reduce to a great extent the frequency of oil changes in a given system.

HEAT EXCHANGE OILS—Heat is essential in mold platens, extrusion press cylinders and nozzles, dip coating tanks, mill and calender rolls, and so on. The older conception of petroleum as a heat-transfer medium calls for steam refined cylinder oils having high flash points. These oils, however, contain unsaturated hydrocarbons which cause them to deteriorate and form tarry deposits when subjected to elevated temperatures for long periods in the presence of air. Since these tarry deposits soon coat the heating elements and the surfaces of the vessels being heated, the heat transfer rate is soon lowered. Then, to counteract this lowered rate the temperature of the oil is increased. But this only accelerates the oil deterioration rate. So the vicious circle simply speeds up.

Field investigations of heat-transfer liquids over the past few years have shown that temperature ranges from −20 to +500 degrees, Fahrenheit, can be served by relatively light bodied, highly refined, oxidation resistant oils.

In open heating systems operating at atmospheric pressure, temperatures of 350 degrees, Fahrenheit, can be safely maintained without undue vaporization or the formation of explosive vapors if the area is well ventilated. However, when the temperature is to be carried beyond 350 degrees, Fahrenheit, the boiling point of the oil must be raised by



Courtesy Watson-Stillman Company

Quality of the oil used as a fluid medium in this type of press machinery is of paramount importance

exerting a pressure of not over 10 pounds per square inch. Continuous operating temperatures of 550 degrees, Fahrenheit, with intermittent short intervals of 650 degrees, Fahrenheit, are being studied to note the behavior of oil in these ranges. It has been recognized that as 750 degrees, Fahrenheit, is approached, regardless of the pressure that is carried, the zone is reached where oil will crack into gasoline, light oils, and heavy ends. It would appear that temperatures above 500 degrees, Fahrenheit, are best served by some of the commercial heat exchange fluids rather than by oil.

As with the hydraulic fluids, filtering devices improve the efficiency of heat exchanger systems. It has been found possible to keep units functioning at their peaks by allowing the filtered fluids continually to scrub the surfaces free of all deposits that tend to interfere with the free flow of heat.

RUST PREVENTION — Just as presses must operate smoothly and accurately, and the platens must be heated evenly if plastics items of good quality are to be produced at minimum cost, so the molds themselves must be maintained in good condition.

Molds are not always in production, and whenever they are placed in storage—even of the shortest duration—their highly polished surfaces are protected from rust which would destroy the usefulness of the mold even though the rust can subsequently be removed.

When the period of storage is short, washing the molds with a polar type thin film rust preventive having good solvent properties is enough protection. This preventive removes all sweat stains from the mold surface and displaces any water or moisture that may be present. But for longer or an indefinite period of storage the cleaned mold should be further coated with a soft petroleum rust preventive. Similar treatment should be given other machinery spare parts. There is no problem involved in the removal of the coating. The metal surfaces need only be washed with regular petroleum solvents.

LUBRICATION—Roll temperatures not above 350 degrees, Fahrenheit, in plastic mills and calenders of conventional design present no unusual lubrication problems. However, it has been discovered that light lubricants possessing high oiliness and load carrying properties give the equipment better protection than do the heavy-bodied cylinder oils which have been customarily accepted as the best.

There is the possibility that rolls may someday carry a temperature of 550 degrees, Fahrenheit, for the processing of plastics and synthetic rubbers. When and if such equipment goes into production it may be necessary to use hydrocarbon lubricants that become effective in bearing temperature ranges above 500 degrees, Fahrenheit. Then there is the further modification of machine design where a given calender will have some heated and some refrigerated rolls. The presence of two temperature extremes in a single unit will make necessary the use of lower viscosity or more fluid lubricants if unnecessary equipment and service complications are to be eliminated.

Lubricating greases for plastics processing machinery raise few problems. In fact, the toggle joints and stops on a press are almost the only points where special attention is necessary. The difficulty here is that the motion is very slow and purely oscillating. Consequently it is difficult to apply the lubricant at the point of greatest pressure and keep it from being forced from between the surfaces when the press goes into operation. The best protection has been found to be active extreme-pressure greases of pressure-gun consistency compounded so as to provide a strong affinity for metal. This lubricant resists the shearing and wiping effect of the oscillating motion.

There are, of course, many other applications for petroleum in plastics processing equipment. But the biggest mechanical elements—hydraulic presses, mills and calenders, heat exchangers, and molds—have been touched upon. The facts indicate the importance of the selection and use of the correct petroleum product for the correct job.

* * *

OXYGEN TENTS

Made of Clear Plastics
In Small Size

MINIATURE oxygen tents for babies born prematurely are now being fabricated from Ethocel sheeting. Still in the experimental stage, the tents consist of a center curved section of heavy gage sheeting and ends of laminated sheeting. The transparency of the plastics material permits a full view of the tiny patient.

COMPACTS

Combine Use of
Metal and Plastics

HOW WELL plastics can work with other materials is evident in the Lucite and silver compacts which are fabricated by Alzac California Jewelry Creations. Assembled entirely by hand, these compacts have lids of black methyl methacrylate to which is laminated the sterling silver design. The base, with its powder compartment, is fabricated from transparent acrylic.

FURNITURE

Uses Plastic Straps
For Comfort and Durability

VINYL elastic strapping forms the backs and seats of "Put-A-Way" folding and demountable garden chairs that can be readily adjusted to different positions. Not only does this Koroseal webbing add a touch of color but it withstands the often damaging effects of outdoor weather.

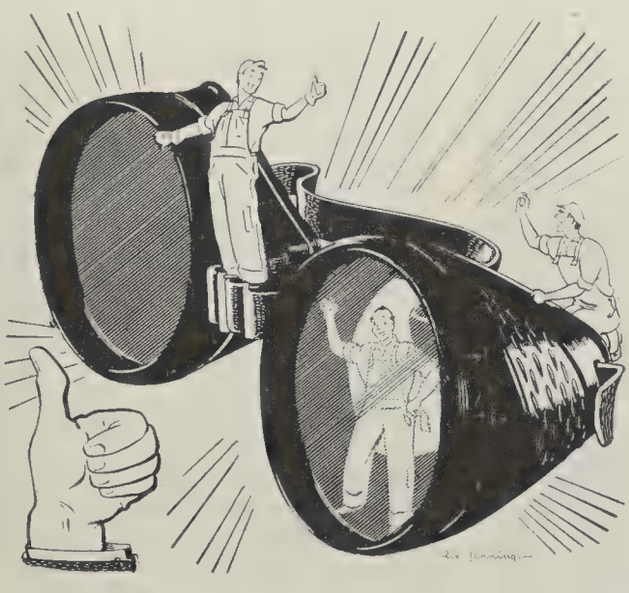
Washable, acid-proof, non-abrasive, the extruded vinyl elastic strappings are resilient enough to conform to the shape of the body and to provide a maximum of bodily comfort—an advantage which is often sadly lacking in summer furniture. The frames of these chairs, which were designed by V. F. V. Gerstel and Ferdinand Kramer of Products Development Division, are built of cypress.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

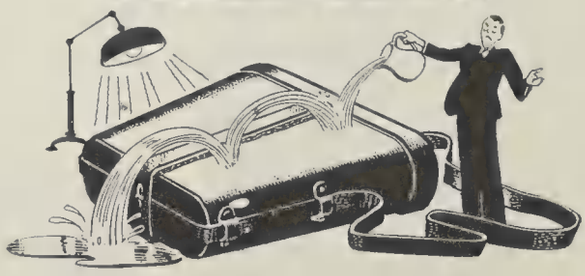
MOLDING COMPOUNDS



THE "EYES" HAVE IT

There are literally thousands of applications for Durez phenolic molding compounds . . . applications which the casual observer is likely to overlook. Bausch & Lomb's "Arc Ban" and "Chip Ban" safety goggles, for example, have eye cups of molded Durez. These possess high-impact strength and are not affected by moisture, sterilization by steam, or most acids. The unusual versatility of the more than 300 Durez phenolic molding compounds has made their use throughout industry practically all-inclusive. Such properties as impact and dielectric strength, moisture, heat, and acid resistance, highest dimensional stability at temperature extremes, diversity of finishes, and excellent moldability make them the logical starting point when you're searching for the plastic that fits your job.

INDUSTRIAL RESINS



LET'S GET DOWN TO CASES

Another interesting application for Durez industrial resins is the war-proved Armed Forces binocular case where a Durez phenolic-impregnated fabric is combined with other materials to form a weather-proof case which is virtually indestructible. Durez impregnating and laminating resins have many new peacetime applications developed from wartime counterparts which promise to be big profit-makers for progressive manufacturers.

OIL SOLUBLE RESINS



NO SENSE "RUBBING IT IN"

Emulsion "no rub" waxes having a wide range of properties can be made with Durez resins. Though all have rich, full gloss films, the films may be varied from those which may be removed with mild soap to those which permit the cleaning of waxed floors without harming the waxed surface. Well-known throughout the entire protective coating industry, Durez resins promise many profitable applications for peacetime markets.



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PLASTICS THAT FIT THE JOB

Chasing Water Pockets

Soft Spots in Railroad Tracks, Caused by Pockets in the Subsoil, Create Maintenance Problems and Frequently Necessitate Speed Reductions. Effective Use of Cement Mixtures is Eliminating Such Pockets Without Interfering with the Use of the Track

RAILROADS have always been accustomed to worry along with occasional "soft spots" in their tracks. As wheel loads have grown heavier, train speeds higher, and the gross tonnage of traffic movement greater, however, this old annoyance has become a problem of major importance. These changes in conditions have all helped to create more miles of soft track; as schedules have been stepped up, the reduced speeds required for safe operation over unstable track become a serious operating embarrassment. Keeping the track on these spots in line and up to grade is an extremely expensive job and most of the former methods of restoring stability interfered seriously with the use of the track.

In recent years a number of railroads, as the result of extensive study and experiment, have learned that a mixture of cement and sand, injected into the affected spots, eliminates most chronic soft track conditions. They have developed effective means of injecting such mixtures, or "grouting," without disturbing the track or interfering with its use.

WHAT CAUSES IT—Soft track is caused by wet subsoil below the rails which, because of its more or less water-saturated condition, has relatively low weight-bearing capacity. Certain spots along a given track, for various reasons are never stable. In such spots frequent additions must be made to the ballast and the subgrade may require occasional refilling to restore the track to its normal surface level. In extreme cases the instability is such that soil squeezed out from under the track dislocates the right-of-way fences.

Such are the occasional soft spots which have long had to be tolerated. Those which have been created or aggravated under the stress of heavy, high-speed traffic arise from the destruction of normal drainage conditions.

When a train passes over a track at high speed, each rail is subjected to a series of vertical loads varying from around five to upwards of 18 tons each, depending upon whether the passing wheels are those of an empty freight car or of a large steam locomotive. In the case of a freight train operating at 70 miles per hour, the impulses, passing along the track in waves of alternately increasing and decreasing load on the rail, occur most frequently in groups of four at the rate of about 15 per second as the ends of the cars pass, the groups recurring at intervals of a half second or less. The rail, ties, and ballast tend to distribute these loads over a considerable area of subgrade, but nonetheless the surface of the subgrade directly underneath the rail is subjected to a series of blows at air-hammer rapidity, the total effect of which is to create pockets in the surface of the subsoil in which water tends to collect and from which there is no drainage. Thus the softening process proceeds and the pockets tend to become deeper until the track instability has to be dealt with.

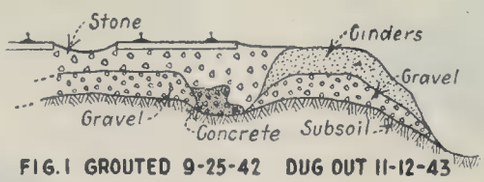


FIG. 1 GROUTED 9-25-42 DUG OUT 11-12-43

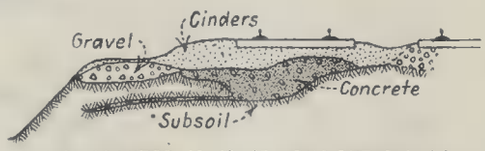


FIG. 2 GROUTED 10-12-43 DUG OUT 8-1-44

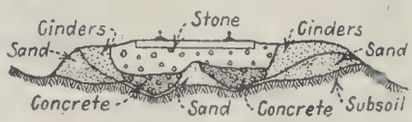


FIG. 3 GROUTED 5-10-41 DUG OUT 6-23-42

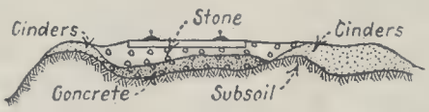


FIG. 4 GROUTED 1-12-42 DUG OUT 6-25-42

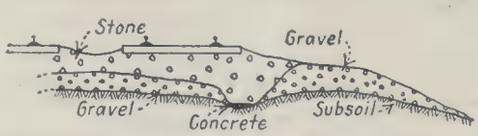


FIG. 5 GROUTED 9-10-42 DUG OUT 10-14-43

Test cross-sections on the New York Central show how the injected concrete grout seals off the soft sub-grade and helps to spread the load over it

SPEED RESTRICTIONS — Where such track conditions have developed, it becomes necessary to add ballast, sometimes at frequent intervals, to restore the sagging track. It may also be necessary, in the interest of safety, to issue "slow orders" limiting train speeds over the soft spots. These slow orders may be removed after repairs have been made, only to be required again in all too short a time as the pocket continues to grow. On important main lines where traffic is heavy, such soft spots may have to be worked on several times a week, and may be subject to speed restrictions for more than half the time.

Not only is such attention very expensive as compared with maintenance requirements on normal track, but the slow orders interfere with the smooth and economical movement of traffic. With passenger trains frequently running on schedules requiring many miles of line to be passed at speeds upwards of 100 miles an hour and freight-train speeds running up to 70 miles an hour, the incidence of enforced speed reductions is far more serious, both as to the number of trains affected and as to the disruption of schedules, than they were two or

three decades ago when top speeds in the two services were more nearly 60 and 50 miles an hour, respectively.

REMEDIES—Methods of remedying these conditions have included installation of special drains, digging out and backfilling the pockets, and even removing the track to permit placing wood or concrete mats to distribute the track loads over a large area. But, even where effective, these methods are expensive to apply and most of them involve serious interference with the use of the track.

About 1940 several railroads undertook investigations and experimental programs intended to develop more satisfactory means of dealing with these conditions. One of these roads, the New York Central, selected six spots for investigation on its Toledo-Detroit branch. At each spot a series of trenches, spaced 25 feet apart, were dug across the roadbed; the bottom in each case was carried down to dry subgrade material. No free water was found in the pockets exposed by these trenches, but the subsoil in the bottoms of the pockets was sufficiently wet to be oozey. The cross sections also disclosed invariably that the point at which the pockets were deepest was directly under the rails.

The investigations of this and other railroads led to the conclusion that whatever treatment was developed should cut off the supply of moisture from the subsoil in the water pockets, and that whatever material was used should be forced into the pockets under pressure.

GROUTING—In December, 1940, the New York Central began grouting with a sand-cement mixture at the six test locations already referred to. In an expanding program this work has progressed until, at the end of 1944, such treatment had been applied at over 200 locations having a total length of 36,379 track feet. The future program contemplates the correction of conditions at some 1200 additional soft spots on main-line track, with possibly as many more on branch lines.

The New York Central method comprises the use of a rich 1-to-1 sand and cement grout with enough water to make it soupy; this is injected into the soft spots below the rails by pneumatic pressure. The rich cement mixture not only serves to seal out the water from the subsoil around the water pockets but it develops considerable strength which aids in distributing the traffic load over the bottoms of the pockets.

Essentially, the equipment for grouting these pockets includes a mixing tank, a portable air compressor, a supply of injection pipes, a pneumatic hammer suitable for driving the injection pipes into place, suitable lengths of air and grout hose, and portable water tanks.

The injection pipes are driven through the ballast outside the ends of the ties, using the pneumatic hammer on the capped ends of the pipes. The pipes are slanted to bring the end as nearly as possible directly under the rail when it has reached well into the pocket. Then the water, cement, and sand for a batch of grout are mixed and the grout forced into the water pocket through an injection pipe. The quantities injected are said to have varied up to as much as 50 one-sack batches through a single injection pipe.

LEAN MIXTURES—Another road which has made an intensive study of the soft-track problem is the Atchison, Topeka & Santa Fe. For a number of years prior to its adoption of cement grouting, this road had been trying to find a practicable means of filling water pockets with a very fine drifting sand commonly known as "blow" sand, of which there are quantities available at many points west of Kansas City. That water could be sealed out of the pockets with this material had been proved by experience with soft spots which had been dug out and back-filled with it.

Based on this experience, unsuccessful efforts were made to inject dry sand into water pockets with air pressure. Then in December, 1941, the Santa Fe began experimenting with cement grout pumped into the pockets. It should be noted



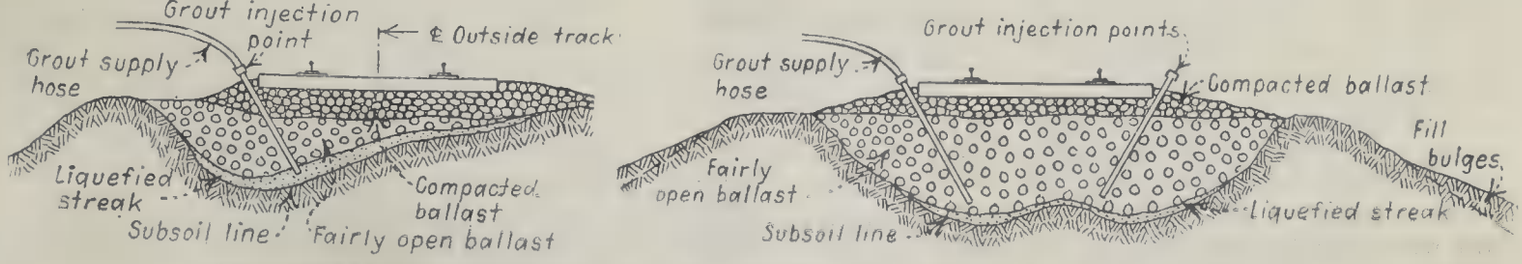
Two crews at work grouting soft spots in track of New York Central System

that, unlike the New York Central and other roads, the objective of the Santa Fe was confined to sealing out the water and restoring original drainage conditions. The cement and water served as a lubricant to enable the blow-sand grout to penetrate and fill all the voids: no thought was entertained of creating concrete "beams" under the rails.

The initial experiments were made with mixtures ranging from one part cement and six parts sand, to one part cement and 13 parts sand. Eight gallons of water were introduced for each cubic foot of dry mixture. This grout was injected into the pockets under 100 pounds per square inch air pressure.

Research has continued since these early experiments. Many variations in the richness of the grout mixtures have been tried, and numerous materials have been substituted for blow sand. In the end, however, the best combination was found to be within the original range of cement-sand mixtures, and the fine sand—the finer the better—was found to be the most effective material.

EMULSIFIED ASPHALT—In 1944 extensive laboratory experiments were undertaken in co-operation with the Texas Company in an at-



Cross-sections showing locations of injection pipes for filling different types of water pockets under tracks

tempt to work out a combination of asphalt and cement for use in track grout. The results were encouraging and after a series of track trials a grout consisting of one part of either Portland cement or mortar cement to 6 to 20 parts of sand, to which were added 1/5 to 1/10 gallon of emulsified asphalt per cubic foot of sand and from 4½ to 8 gallons of water for each cubic foot of dry material, was finally adopted as most satisfactory. This formula gives the same penetration and is considered even better in water-sealing properties than the richer cement-sand mixture.

Much of the experimental work done by the Santa Fe has been devoted to the improvement of methods and equipment for getting the grout into subsoil. One of early developments was the substitution of hydraulic for pneumatic injection. The latter was slow and otherwise unsatisfactory and a piston-and-cylinder grout pump which forces the mixture into the roadbed under a maximum pressure of 450 pounds per square inch was developed. Then began the successful development of complete mechanical equipment for mixing and injecting the grout as a continuous process.

Unlike the New York Central, the Santa Fe method involves driving holes into the water pockets and then inserting injection pipes into the holes. The holes are spaced about 5 feet apart. Since May, 1942, the Santa Fe has grouted wet spots aggregating considerably more than 50 track miles in length.

COSTS RETURNED—Results so far observed have shown satisfactory improvements in track stability and reduction in maintenance costs. For instance, on the New York Central system, two soft spots not far apart, aggregating 312 feet in length, were grouted at a cost of $300.88. Prior to grouting these spots required maintenance at least three times a week at a cost of $248.96 a month. Grouting reduced these costs to $17.70 a month. The grouting thus returned its cost in savings in maintenance within less than 1½ months. While the aggregate results are not as striking as this specific example, they are highly satisfactory.

One of the oldest sections of grouted track on the Santa Fe involves 4.2 miles of single-track main line over which speeds up to 100 miles per hour are permitted. In 1940 slow orders had been in effect on this track for 262 days of the year. In 1941, after an attempt was made to improve the track, it was still necessary to keep slow orders in effect on a 1½ mile section for 163 days during the year. This track was grouted in 1942. Since the work was completed no slow orders have been required at this location. The cost of stabilization is said to have been returned within one year by the reduced expenditures required for maintenance.

From the standpoint of the American traveling public this development spells better riding qualities of passenger trains, the on-time performance of which will be progressively improved as the number of soft-spot speed restrictions are reduced.

• • •

DRAGGING EQUIPMENT

Spotted Before Loose Parts Can Cause Derailment

OCCASIONALLY, but rarely, some part of a railway car truck may fail in such a way as to drop down and drag along the track. To avoid the hazard which such parts cause if they are dragged into a switch, where they may catch and derail the car, the Pennsylvania has installed dragging-equipment detectors on its main tracks.

Each installation consists of four castings, the tops of which are made of U-section bars. These are placed across the track, two between the rails slightly below the level of the top of the rails and one outside each rail. These castings are connected in an electrical circuit which energizes a relay that in turn controls the circuits for the next interlocking home and distant signals. The detectors function by being broken by the dragging member, thus interrupting the electrical circuit.

These detectors are located a suitable distance ahead of the roadside signals so that the breaking of a detector allows the signals to come to the most restrictive aspect in time to permit the engineman to stop the train at the home signal. When the train stops, the signal-tower operator advises the crew that the dragging equipment detector has functioned. The crew then inspects the train and repairs or removes the affected car.

ALUMINUM TANK

Still in Excellent Condition After 17 Years

THE FIRST aluminum tank car was built in 1928 by the General American Transportation Corporation. In August, 1945, it had been in service for 17 years. At the outset it was handling glacial acetic acid for the Niacet Chemical Company and since March, 1930, it has been assigned exclusively for the handling of glycerin for Procter and Gamble. During this period it has traveled 408,000 miles and, except for minor running repairs, was shopped but five times. The tank itself has never required any repairs, beyond replacements of aluminum heater pipes. The only repairs had to do with the trucks, brakes, and draft gear. The tank, built of Alcoa 3S alloy, was butt welded throughout by the gas process.

This tank has a capacity of 8000 gallons and was designed for a working pressure of 25 pounds per square inch. Weighing 33,900 pounds, the car represented a saving of about 8300 pounds as compared with a steel tank of the same capacity. It and other aluminum tanks subsequently built have demonstrated the ability of this material to transport such commodities as glacial acetic acid, hydrogen peroxide, glycerin, formaldehyde, naphthenic acid, nitric acid, and other chemicals and food stuffs in bulk which do not require a special tank lining.

RAILROAD RADIO

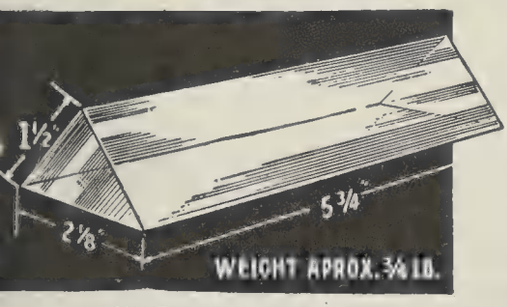
Network Uses Portable Frequency-Modulation Sets

EQUIPPED with mobile frequency modulation radio sets in an industrial version of the Army's "walkie-talkie," five Diesel-electric locomotives of the Westinghouse Electric Corporation now roll over 25 miles of switchtracks in Pittsburgh, their crews in constant radio communication with the yard office.

The new static-free radio communication system which allows two-way conversations between engine and yard office, quickly proved its worth. Now, instead of the engine running back to the yard office for instructions, the yard office communicates with the engine crew in any part of the yard and gives instructions. The saving in time and also in the physical labor of throwing switches, which was necessary when engines had to keep running back and forth to the yard office, has speeded up the movement of freight in the yard. Where, heretofore, hours were consumed in moving certain cars, minutes are now required.

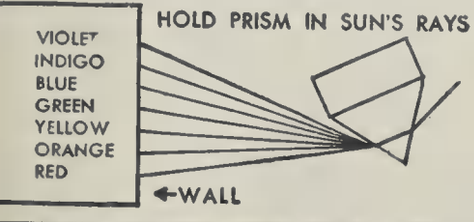
The little network consists of five mobile stations on the five locomotives and one stationary transmitter and receiving set in the yard office. Frequency modulation radio was chosen because of its elimination of static.

SENSATIONAL WAR BARGAINS in LENSES & PRISMS



SILVERED TANK PRISM
Stock #3004-S.....$2.00 Each Postpaid

PLAIN TANK PRISM
Stock #3005-S.....$2.00 Each Postpaid
FOUR TANK PRISMS—Special.....$7.00 Postpaid
. . . The most sensational bargain we have ever been able to offer.



TANK PRISMS

In order that the tank driver shall not get shot in the face, 2 of these Silvered Prisms are used to make a Periscope. We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree Prisms of huge size—5¾" long, 2⅛" wide, finely ground and polished. Used to build a Periscope . . . excellent also for experiments, classroom demonstrations. Some of our ingenious customers have used these prisms to make camera stereo attachment, range finder, etc. Prism easily converted into desk name plate by affixing gold letters. 100 supplied at only 10c. (Order Stock #3008-S.) Normally these Prisms would retail from $24 to $30 each.

TO SEE THE COLORS OF THE SPECTRUM, hold a plain tank prism in sun's rays as shown in drawing. White incident light which passes through prism is thus broken up into a band of primary colors known as the spectrum—a beautiful sight! By looking through a tank prism at a certain angle, you can see a world of colors everywhere. Truly amazing!

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked

YOU CAN EASILY MAKE

Telescope, Magnifiers, Photographic Gadgets and Hundreds of Experiments with these Low Cost Lenses. Excellent also for XMAS gifts.
To translate millimeter measurements: 25.4 mm. equal one inch.

8 MM. MOVIE PROJECTING LENS SET—Consists of 2 Achromatic Lenses, Diam. 15 mm. and a F.L. when combined of approx. one inch. Each lens has the new magnesium fluoride low reflection coating.
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16 MM. PROJECTING LENS SET—Consists of 2 Fluoride coated cemented Achromatic Lenses 1 inch diam. with combined F.L. of 2 inches.
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MONOCULAR SET OF LENSES AND PRISMS . . . From Navy's 7 x 50 Binocular. All the optics you need to make a 7 Power Monocular. Complete Directions included.
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MICROSCOPE SETS

Consisting of 4 Cemented Achromatic Lenses for making a 40 Power Pocket Microscope or 140 Power regular size Microscope. These color corrected Lenses will give you excellent definition and may be used for Micro-photography.
Stock #1037-S.....$3.00 Postpaid

Consisting of Prism, Mirror and Condensing Lens. These used together with Stock #1037-S will make an excellent micro-projector enabling you to get screen magnification of 400 to 1,000 Power according to screen distance.
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SPECIALS IN LENS SETS

Set #1-S—"Our Advertising Special"—15 Lenses for $1.60 Postpaid, plus 10-page idea booklet. For copying, ULTRA CLOSE-UP SHOTS, macrophotography, experimental optics, magnifying and for making a two power 7/16 Telephoto Lens, "Dummy Camera," Kodachrome Viewer, DETACHABLE REFLEX VIEWFINDER for 35 mm. cameras, stereoscopic viewer, ground glass and enlarging focusing aids, TELESCOPES, low power Microscopes and for many other uses.

Set #15-S—"The Experimenter's Dream"—62 Lenses, Prisms and Optical Items, and New 50-Page Book, "Fun With Chipped Edge Lenses." $15.00 Postpaid. The variety of Lenses and Prisms in this set will enable you to conduct countless experiments, build a great variety of Optical Equipment. A sensational buy.

NEW 50-PAGE IDEA BOOK "FUN WITH CHIPPED EDGE LENSES"
Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above . . . only $1.00 Postpaid.

POLAROID (Dyed)—Suitable for Experimentation. Consists 2 discs—2½" diam. Some imperfections in glass.
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LENS FOR KODACHROME EYE-VIEWER . . . Color corrected cemented lens 41 mm. diam., 66 mm. FL.
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MISCELLANEOUS ITEMS

Stock No.	Item	Price
3016-S	Pentagon Prism. Each	$0.75
2024-S	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm.—for making Filter)	.25
3021-S	Amici Roof Prism (3rd Grade). Each	.25
4009-S	Heat Absorbing Glass 4" x 5". Each	.35
4010-S	Heat Absorbing Glass 2" x 2". Each	.10
3020-S	Right Angle Prism 48 mm. wide (3rd grade). Each	.35
523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼". Each	.25
624-S	Neutral Ray Filter size 4¾" x 2½"	.25
3022-S	Round Wedge 65 mm. Diam. Each	5.00
3036-S	Roof Prism — 80 degree, face 1⅝" wide. Each	4.00
22-S	Inclinometer—Aircraft type. Each	.25
704-S	Lens Cleaning Tissue, one ream (480 sheets), size 7½" x 11"	1.50
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Stock #1500-S—Hand Type Spectroscope..$3.45 Postpaid
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Power of either 5, 6 or 10.....$1.60 Postpaid
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Small 2 Power Pocket Scope.....$1.00 Postpaid

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Stock #5010-S— 6 Power Telescope..$3.00 Postpaid
Stock #5011-S—11 Power Telescope.. 3.25 Postpaid
Stock #5012-S—20 Power Telescope.. 7.25 Postpaid

COLOR FILTERS

1 Red and 1 Yellow Filter in following Diam.
20 mm. .....(seconds).....40c
32.5 mm. .....(seconds).....70c
37 mm. .....(seconds).....70c
45.5 mm. .....(seconds).....90c
31 mm. .....(seconds).....70c
(Minimum Order on Above—$1.00)

CLEANING BRUSH SET . . . For Lenses, Optical instruments, etc. Perfect quality—12 inch flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
Stock #504-S—(Reg. $6.00 value).....Price $1.00 Postpaid

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Stock No.	Type	Base Width	Base Length	Price
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3042-S	Right Angle	41 mms.	40 mms.	1.00
3045-S	Right Angle	70 mms.	168 mms.	8.00
3001-S	Lens Surface	20 mms.	14 mms.	2.00
3009-S	Porro	52 mms.	25 mms.	1.00
3016-S	Pentagon	45 mms.	22 mms.	.75
3029-S	Dove	16 mms.	65 mms.	1.25
3036-S	80 Degree Roof	60 mms.	36 mms.	4.00
6136-S	Rhomboid	20 mms.	17 mms.	.50

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Complete Set Mounted Components

Rugged, strong, originally constructed for U. S. Tank Corps. Consists of fine Periscope Mirrors mounted in metal and plastic. Perfect condition. Only plywood body frame is required to finish this exceptional Periscope. First surface mirror is well protected by glass windows. Set weighs 2¾ lbs. Overall length of mount 6⅛", width 2⅛". Would normally retail at $40 to $50.
Stock #700-S....$3.00 Complete Set Postpaid
TWO SETS (4 UNITS).....SPECIAL $5.50 Postpaid

ORDER BY SET OR STOCK NO. ✣ SATISFACTION GUARANTEED

EDMUND SALVAGE COMPANY • P. O. AUDUBON, NEW JERSEY

An Expanding Chemical

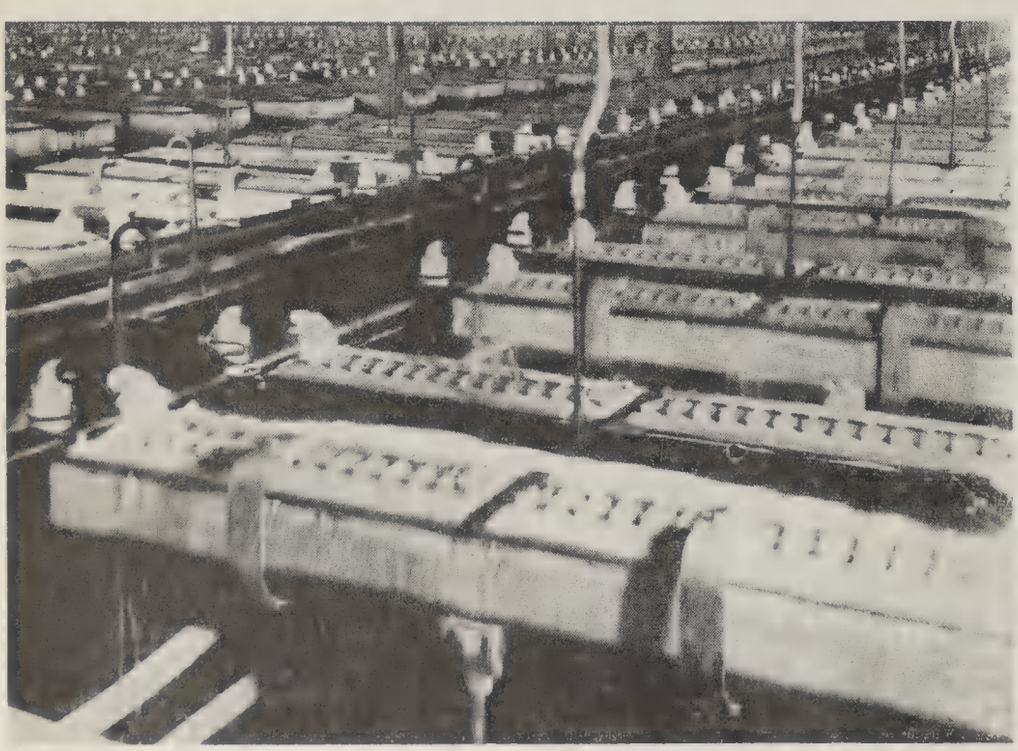
Sodium Methylate, Now Available Commercially, is Used in Drugs and Cosmetics, in Perfumes and Lacquers, in Dyes and Insect Repellants

KNOWN as a laboratory product for some time, sodium methylate is used in research and is essential in the manufacture of sulfadiazine and a number of other products. But its use in industry has been limited because, until recently, there was no "ready-made" sodium methylate on the market.

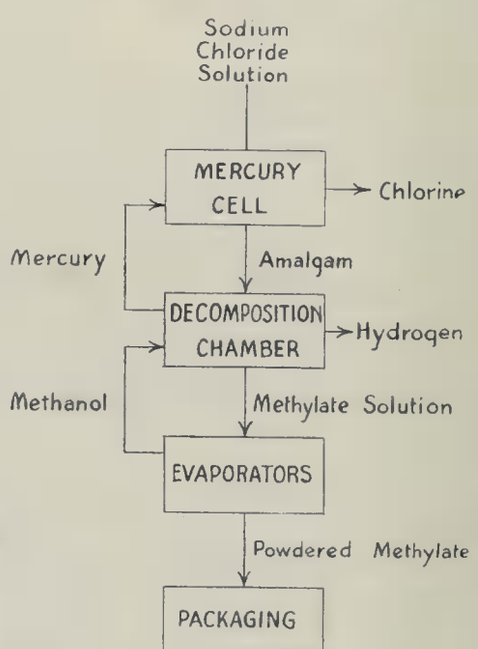
Whenever methylate has been needed, the user has had to make it himself, by dropping small pieces of metallic sodium into methyl alcohol. The resulting solution is not completely satisfactory where high yields of certain products made from the methylate are desired, since it may contain various impurities and may be too dilute. Now, however, the chemical is being made on a commercial scale.

HOW MADE—Commercial sodium methylate may be made by a modification of the Castner electrolytic process which has been used for years to produce chlorine and caustic soda. In the Castner process, brine is electrolyzed in a cell containing mercury as its cathode. The sodium chloride is separated into its elements, the sodium combines with the mercury to form sodium amalgam, and chlorine gas is liberated at the anode. When sodium amalgam is treated with water, the sodium reacts to form sodium hydroxide (caustic soda) and hydrogen, and the mercury which remains is returned to the electrolytic cell.

In the production of sodium methylate in The Mathieson Alkali Works, the same process is used, but the amalgam, instead of being treated with water, is brought into contact with methyl alcohol (methanol). The sodium amalgam is circulated through a specially designed contact tower (or decomposition chamber) which is packed with pieces of graphite flooded with the amalgam. Methyl alcohol preheated to reaction temperature is forced in at the bottom of the tower under sufficient pressure to overcome the head of amalgam in the tower. The sodium in the amalgam reacts with the alcohol, producing gaseous hydrogen and a solution of sodium methylate, as the amalgam and alcohol move in opposite directions along the pieces of graphite. The mercury is returned to the Castner cell from the bottom of the contact chamber by means of a riser. The solution of methylate and the hydrogen formed with it are separated at the top of the tower. The methylate alcohol is then evaporated from the solution to give a white, dry powder containing at least 95 percent methylate. The powder is packaged in airtight containers to prevent reaction with components of the atmosphere.



Castner mercury cells in which the salt is electrolyzed into its elements, sodium and chlorine. The sodium forms an amalgam with the mercury and is then treated with methyl alcohol in a reacting tower to form sodium methylate which is dryed and packed



Flow diagram of sodium methylate commercial manufacturing process

DRUGS AND EXTRACTS—Among the drugs, in addition to sulfadiazine, which require sodium methylate in their manufacture are sulfamerazine, atabrine (the quinine substitute), the barbiturates (vero-

nal, phenobarbital), and some of the vitamins.

The perfume industry, too, uses considerable quantities of sodium methylate. Flowers owe their scent to chemical compounds—aldehydes, ketones, and esters. When synthetic perfumes are manufactured, similar compounds can be prepared with the help of sodium methylate. For example, nonaldehyde is used in making rose oil, benzaldehyde for heliotrope perfume, methyl nonyl ketone for the sweet pea odor, and ionone for violet perfume.

Sodium methylate is useful in the food industry for the preparation of flavorings, essences, and extracts—compounds which are chemically similar to scents.

In the field of cosmetics, sodium methylate is used to prepare a variety of beauty preparations, including a light screen medium for sun tan lotions and creams.

OTHER USES—Sodium methylate is used in preparing xanthates, required in metallurgy to extract copper, lead, and zinc from their ores by the flotation process.

Components of nitrocellulose lacquers involve the use of sodium methylate. The solvent for the lacquer and the plasticizer added to make the film strong and pliable are made with the help of this versatile chemical.

Methylate is widely used, both in research and industry, for the preparation of organic intermediates—chemicals used in the preparation of other chemicals. One of these is acetoacetic ester, used in the manufacture of innumerable compounds. These include many dyes and pigments, such as the "Hansa Yellows," used in lacquers and inks, and the pyrazolones, used in textiles because of their fastness to light. Among the new insect repelling compounds is indalone, a product also prepared from methylate intermediates.

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EXPANDING RESEARCH

Predicted by Educator As Result of War

A RAPID expansion of industrial research after the war was predicted by Dr. Harvey N. Davis, President of Stevens Institute of Technology, in a recent address before the American Society of Refrigerating Engineers.

"American post-war industry will be definitely on the move," he said. "It will be changing rapidly. The total volume of production will, we all hope, continue to be as it is now, greater than ever before in our history.

"The kind of things produced will be very different from our present output, and probably different in many significant respects from prewar production. And the keynote of all this change is going to be industrial research. Even if one prefers to limit the term to what goes on in our 2000 to 3000 industrial *scientific* laboratories, it is still true that active vigorous industrial research will be a far more important factor in post-war industry than was ever before the case in this or any other country.

"The first World War, and particularly the spectacular developments in military aviation, drew general attention both to the actual and to the possible achievements of applied science, and by 1940 the number of industrial research laboratories was more than seven times that of 20 years before. There is every reason to expect that the after-effect of the present war will be even greater.

"Furthermore," Dr. Davis continued, "this country has experienced an immersion in war research in the last two or three years that is



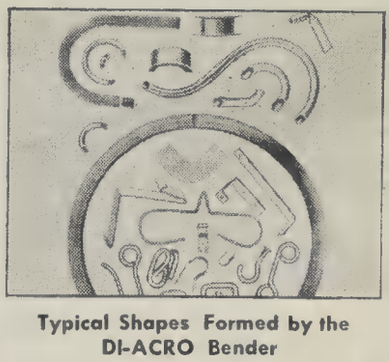
"Die-Less Duplicating" Eliminates Time Loss and Die Expense!

The DI-ACRO Bender is a precision unit, designed to form and duplicate an unlimited variety of parts and pieces—eliminating, in many cases, the need for special dies. Tubing can be accurately formed with the DI-ACRO Bender to a center line radius as small as 2½ times the outside diameter of the tube without distortion. Shapes and outlines, impossible to obtain with regular production dies, are easily formed with the DI-ACRO Bender. These include round, half-round, hexagon, and square rod, tubing, angle, channel, moulding, strip, stock and bus bar.

Stops may be set and material guides mounted for production work in excess of 1000 operations per hour. The Bender is compact and portable, ideal for temporary or permanent work. There are no extra parts to purchase, as the DI-ACRO Bender has been built to cover a wide working range, with simple conversions.

Peacetime production for industry, forecasts the return of Wrigley's Spearmint Gum—that favorite "help on the job," for workers everywhere. But Wrigley's Spearmint will be back only when conditions permit its manufacture in quality and quantity to meet your needs. Until that day, we ask you to remember the famous Wrigley's Spearmint Wrapper shown at right, as your guarantee of the finest chewing gum that can be made.

You can get complete information from O'Neil-Irwin Manufacturing Co., Minneapolis 15, Minn.



Typical Shapes Formed by the DI-ACRO Bender



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bound to be contagious. Even our Office of Production Research and Development in Washington had more than twice as large a research fund at its disposal during the fiscal year of 1943-44 as was initially allotted by Parliament some 12 years earlier to the whole of England's national Department of Scientific and Industrial Research. Also during that same year 1943-44 the Office of Scientific Research and Development had a budget something like 12 times as large as O.P.R.D.'s, and I have no doubt that the funds directly spent on research by the armed services were even larger. A very large proportion of these vast expenditures bore more or less spectacularly useful fruit. This concentrated national experience with research is sure to have an important influence on post-war industrial thinking."

CABIN-CAR

Will Provide Privacy For Day-Night Travel

AN 85-foot railway sleeping car which will have 22 unusually commodious private rooms, all on one level, designed to satisfy the need for individual day-and-night accommodations and provide every possible comfort at a nominal tariff, was recently announced by the Edward G. Budd Manufacturing Company. In this new "Cabin-Car" the beds are to be six feet four inches long and 35 inches wide. Beds will be lowered into place or returned to their daytime positions electrically by the flick of a switch. The bed frames supporting the springs will be of lightweight magnesium, the mattresses of foam rubber. When the bed is in night position, a case for valuables and a combination bed and night light will be conveniently located.

In daytime a deep cushioned, wide, adjustable chair-type seat with curved head rest is provided. With



Daytime make-up of cabin-car

the club-type arms folded the seat is wide enough for two. A clothes closet, toilet, and stainless-steel wash basin are fitted into the aisle wall of each room. The top of the toilet, arranged as a second seat, is upholstered to match the chair.

Heated or cool air, controlled by thermostats, for ventilation, is provided through an overhead diffuser outlet, behind which is concealed a semi-circular fluorescent tube, providing general indirect lighting. Secondary lights are also fluorescent. Baggage space is large enough for a full sized suit-case. A locker above the wash basin contains a water carafe, glass, and drinking cups. An electric outlet is provided for razors and curling irons.

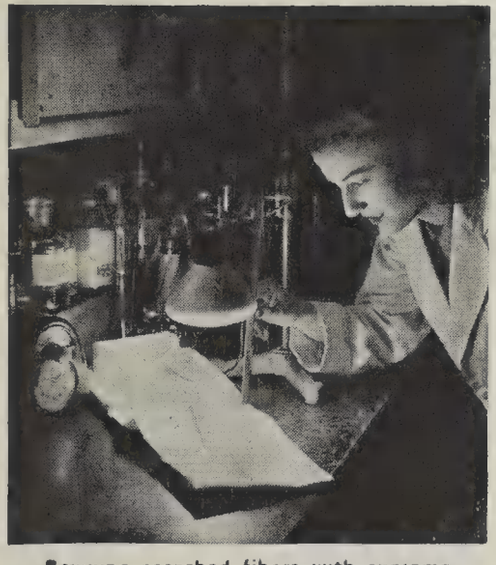
Sound deadening features have been employed throughout the car, which is of Budd standard stainless steel construction.

SCORCHED FIBERS

Revived by Application of Ultra-Violet Rays

BY BRINGING grandmother's bleaching technique indoors, engineers have developed a scorch-removing process which will make extra thousands of scarce white shirts available to men in the next year.

Instead of summer sunshine, a large shirt manufacturer is now using a standard electric sunlamp to eliminate scorch marks. In effect, explains Eugene W. Beggs, Westinghouse vapor lamp specialist, the



Reviving scorched fibers with sunlamp

long-wave ultra-violet rays generated by the lamp administer a water transfusion to parched fibers of shirts scorched slightly during ironing.

Irradiating previously dampened singed areas, the ultra-violet pumps the moisture into the fibers, restoring the shirts to their original whiteness in ten minutes. The phenomenon is the result of a photochemical action, or the ability of visible and invisible light rays to cause a change in the chemical makeup of matter which absorbs those rays.

"Grandmother probably never heard of photochemistry or of ultra-violet rays," says Mr. Beggs, "but she took advantage of them when she bleached her white clothing and linens under the ultra-violet radiations of the summer sun. That is why we adapted the sunlamp for the job."

The bleaching process was developed primarily for commercial use but eventually the housewife and hand laundry may adopt a similar scorch-removing method. Ultra-violet also may offer a valuable bleaching tool for the entire textile industry, Mr. Beggs adds.

He estimates that the sunlamp process during the coming year would expedite shipments of more than 10,000 shirts from one shirt plant alone.

The parched area in the shirt is dampened and the shirt is placed five inches distant from the lamp, which is three times more powerful in its bleaching and suntanning properties than natural sunlight. After 10 minutes' exposure, the scorch is eliminated. By using the sunlamp in this manner, results are quicker and better than those obtained under rays of a summer sun.



A portion weighing operation in the Consumer Service Test Kitchen of Armour and Company, Chicago, Illinois.

Check Your Portions—

The simplest way to control food costs is to check individual portions every day. Weigh them! Failure to follow this practice is the most common weakness in the food field. Oversized portions lack uniformity . . . worse still they are unprofitable. Remember one-half ounce over per portion is pennies today, dollars in a month, several hundred dollars in a year . . . profits melting away. EXACT WEIGHT Scales stop these losses . . . are sound equipment for profitable operation. Eliminate a real LEAK in your business by writing for full information covering these types of scales. Do it today!

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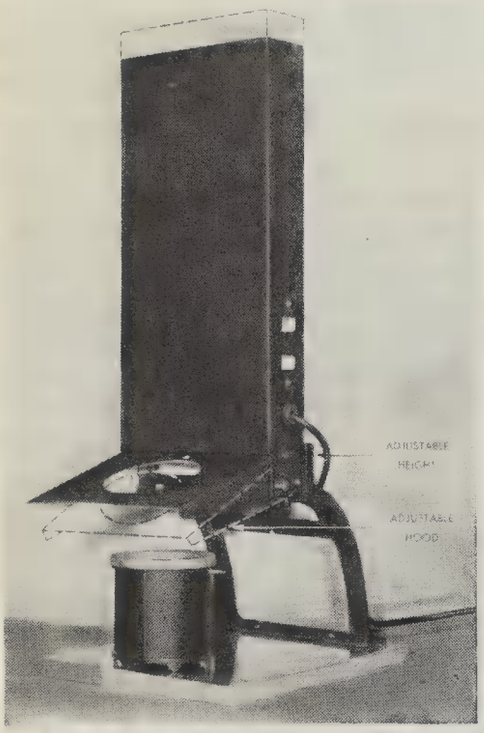
New Products and Processes

SOLDERING STAND

Features Adjustable Hood And Fume Stack

EMBODYING the flexibility required for soldering with iron, torch, or soldering pot, the hood and fume stack of a new soldering stand can be raised and lowered to accommodate any of the three heating elements used in soldering.

This SS11 soldering stand, developed by the Ess Specialty corporation, permits interchangeable soldering, greater protection against injurious fumes, minimizes hand fatigue, eye strain, and so on, and increases soldering production and efficiency.



Three different types of soldering can be accomplished in this stand because of flexibility of its design

Soldering with this stand allows maximum freedom for work passing and enables the operator to focus attention on the soldered joint by means of the plate-glass window (or magnifying glass) in the hood, thus quickening the soldering pace by elimination of lost motion.

GAS PACKING

Preserves Foods From Effects of Oxygen

A PROCESS which may some day match the popularity of "vacuum packing" as a guarantee of flavor freshness in canned foods such as coffee, nut meats, candy, and dehydrated products, is "gas packing." Both processes have the same purpose—to prevent rancidity, off-flavor, and vitamin loss by eliminating oxygen from the containers in which the foods are packed.

According to R. V. Wilson, director of customer research for Continental Can Company, gas packing has been in commercial use for a number of years, but has not enjoyed the publicity that made vacuum packing famous. Each process has certain advantages, but it is impossible to tell which is best for any particular product until specific laboratory tests have been made.

Whereas vacuum packing is the process of drawing air out of a can before it is hermetically sealed, gas packing works on the opposite principle of displacing the air with an inert gas. Actually the two processes are usually combined—the air is first exhausted, and the gas is then allowed to rush in and take its place.

The gases used are either carbon dioxide, the well-known "soda-pop" gas, or nitrogen, which makes up 78 percent of the atmosphere. Both gases are harmless, and do nothing but take up space.

"Oxygen has always been a troublemaker in the preservation of certain foods," Mr. Wilson says. "Unquestionably, its greatest deleterious effect is upon flavor. Rancidity and staleness are caused by the oxidation of natural oils. This rate of oxidation is affected not only by the amount of oxygen available, but also by the moisture content of the product and the catalytic effect of light." However, when foods are vacuum or gas packed in hermetically sealed containers, no oxidation can occur and the foods remain fresh as originally packed.

He also points out that it is immaterial whether a vacuum exists in the container or not so long as the amount of oxygen present is low enough to preserve the product. Common practice is to limit the amount of oxygen to 1 to 3 percent.

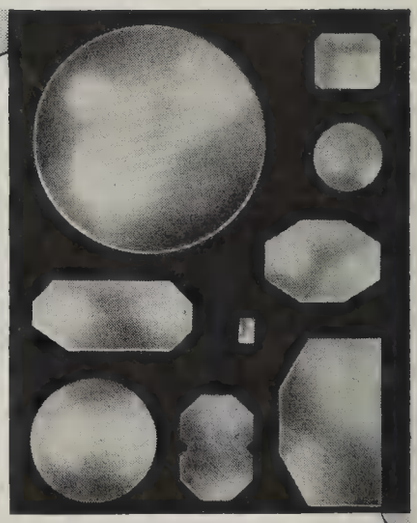
One of the advantages of gas packing, according to Mr. Wilson, is that it permits packing any size container with an extremely low oxygen content. Since the containers are then sealed at atmospheric pressure, there is also less likelihood of subsequent strain or air leakage.

ACID-PROOF WOOD

Produced by Plastics Impregnation

STRUCTURES exposed to rapid deterioration by contact with acid solutions or fumes can be made acid-resistant through use of a plastics-impregnated

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wood. Such acid-resistant wood has been found to be sound and firm after 18 months service when untreated wood under identical conditions lasted only two to three weeks.

The plastics treating material, developed by Koppers Company, Inc., is liquified by high temperature and the wood to be processed is immersed in the compound in sealed retorts. The plastics is forced deeply into the wood fibers by high pressure at temperatures sufficiently high to hold the compound in the liquid state. After an impregnation period of 10 to 20 hours, the compound sets-up as a plastics-solid distributed in the cells of the wood as it is allowed to cool, to produce the material known as Asidbar. The treatment increases the weight and hardness of wood, and gives it a black surface which need not be painted; resistance to wear and abrasion, water and chemicals is considerably increased. The properties of Asidbar make it suitable for many requirements of severe service conditions at temperatures up to 180 degrees, Fahrenheit.

Wood thus treated is non-toxic and can be installed with ordinary woodworking tools.

PRINT MACHINE

Uses Dry Developing Method

RAPID and automatic reproduction of engineering and architectural drawings, printed matter, office forms, specification sheets, letters, advertising layouts, and a wide variety of other materials, is possible with a new machine developed by the engineering department of the Ozalid Division of the General Aniline and Film Corporation. Known as the Printmaster, this machine will print and dry develop as much as 30 feet of material a minute, producing positive prints, which have blue, black, red, or sepia lines on a white background. These prints may be reproduced on paper, cloth, foil, or film.



High-speed, versatile printing unit

These materials are sensitized with special azo dyes which react in the presence of ammonia vapor, which is the developing agent employed in the Printmaster. They require no washing, drying, or fixing, as is the case in blueprint and the "wet" processes. In addition, this same machine can be used to produce photographic prints in a matter of seconds without the use of wet developing solutions.

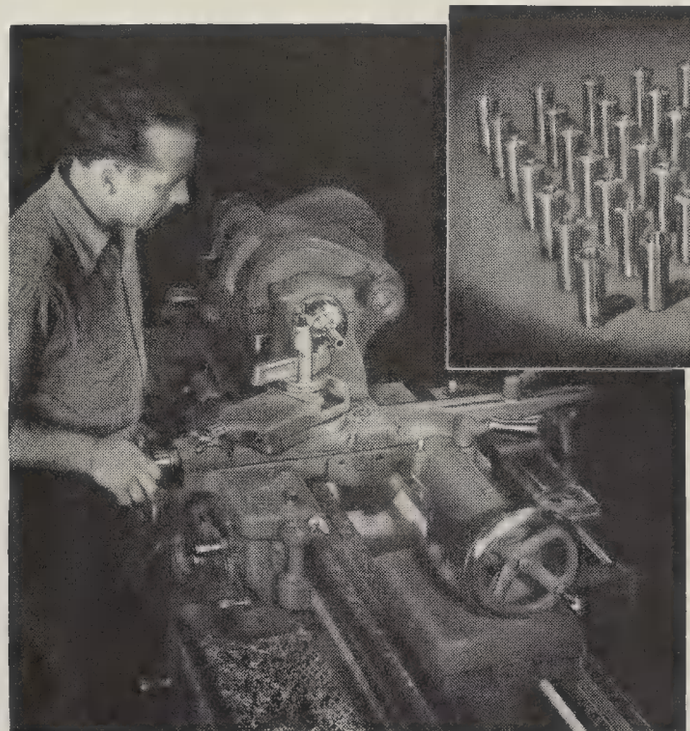
Versatility *for Precision Toolroom Work*

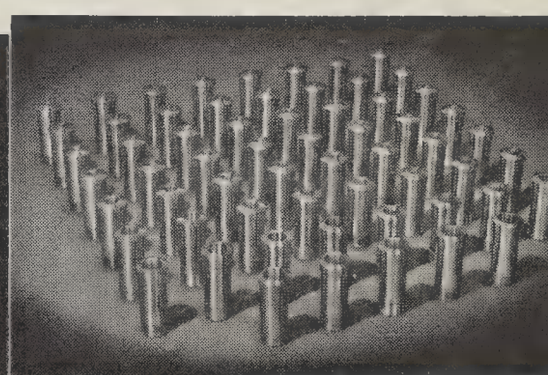


The ease with which South Bend Toolroom Lathes can be changed from one set-up to another for an almost unlimited variety of precision operations is one of the reasons for their popularity in the busy toolrooms of war-rushed essential industries.

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LAMINATE PLASTICS

Can Be Made in Any Color or Thickness

COLORFUL and lightweight refrigerators, luggage, and furniture of any size, shape, or color you want, made from a new cellulose plastics laminate, is a post-war possibility, according to the Hercules Powder Company.

Made like a sandwich, the cellulose laminates actually are tougher than steel of equal weight, lighter than aluminum of equal thickness, and have unlimited color possibilities.

To make the laminates, pieces of textile, paper, or similar material are coated with ethyl cellulose or cellulos acetate, stacked, inserted between tw highly coated stainless steel plates, an placed in a press. Under heat and pres sure, the plastics textile combination i welded into one sheet of laminate.

The thickness of the finished laminat sheet, determined by the number o plastics-coated textile pieces stacked varies according to the use for whic the laminate is designed.

The inherent strength of the cellulos derivatives is greatly reinforced by thi laminating technique. Some of th laminate samples cannot be broken o standard plastics impact strength test ing equipment.

Industrial design artists will be abl to let their imaginations run rampan when thinking about new article made from cellulose laminates, becaus color possibilities are endless. For ex ample, plaids, flowered designs, an prints can be imbedded in the laminat to create products of deep, lastin beauty.

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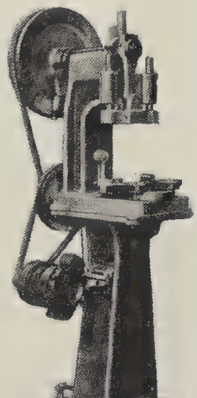
sive equipment. Operations such as drilling, punching, and riveting usually are unnecessary because the plastics in the laminate sheets forms its own adhesive, or a solvent-sealing process can be used.

PUNCH PRESS

Adaptable to Many Different Jobs

An OPEN-FACE punch press, suited to a wide range of small punch press operations, does work fast and accurately in stamping, perforating, blanking, punching, piercing, light drawing, forming and assembly jobs, crimping, die work, and many similar operations.

Unskilled workmen can quickly learn its operation and turn out precision work within exceedingly close tolerances. The press is said to work equally well on metal, cloth, rubber, wood, synthetics, and plastics. The body is heavily reinforced and the slides are designed for maximum wear. Pilot bars are solid ground alloy steel. Automatic wick-oilers provide guide-rod lubrication. The shaft is a hammered steel forging. The clutch is positive and made of heat-treated alloy steel. The flywheel is solid metal, grooved for V-belt drive, and balanced for smooth operation and maximum power.

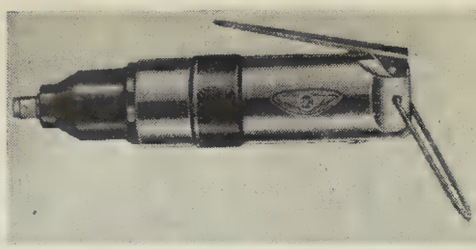


V-belt drive, open face press

IMPACT WRENCH

Eliminates Thread Stretching and Burning

Delivering ample power for stall-proof operation, a ¼ inch capacity pneumatic impact wrench with straight-type grip and lever control is particularly suited to assembly-line jobs of nut-setting and screw-driving. Through its torque control mechanism, stretching or "burning" of threads is eliminated. Control is obtained primarily through the construction of a roller clutch impacting mechanism which consists of only four major parts—anvil, hammer, and two cylindrical steel rollers. When in operation, centrifugal force throws the two steel rollers out against the hammer where they are caught in shear between the hammer and anvil members. This transfers the full torque through to the work in the form of a sudden impact. When the selected torque is reached, the rollers rebound from the anvil face and do not allow the hammer to engage for impact. This method of impacting prevents any stretching of the threads on either the stud or bolt and guarantees maximum torque. The simplicity of design of the roller clutch impacting mechanism insures long life and ease of maintenance. The motor itself is of rugged construction, governor controlled, employing a six-bladed rotor mounted on precision ball bearings and is housed in an aluminum case. The complete tool made by the Aro Equipment Corporation, has been designed for perfect balance and easy handling.



Air-operated automatic wrench

APRONS

Have Strong Neck And Waist Tapes

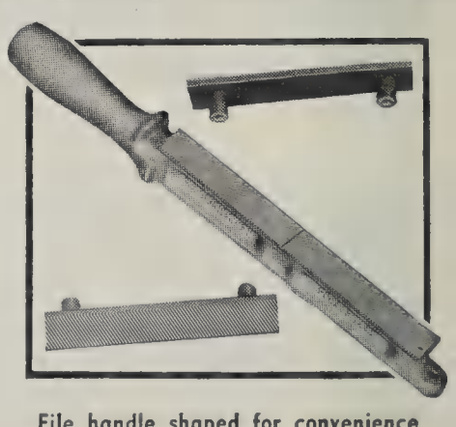
Lightweight and acid, alkali, and oil resistant, a new apron is made from fabric coated on one side with a black vinyl resin, for use in the canning and other industries. Announced by The B. F. Goodrich Company, all edges of the apron are hemmed and the neck and waist tapes are in one piece, sewed into the hem of the arm cut-out, giving the apron strength and rigidity as well as a good drape.

LATHE FILE

Has Easy Replacement Feature

Development of a new lathe file which retains the advantages of previous models in that it will cut steels no ordinary file can cut, at speeds three to ten times faster than steel files, and with a life of from 50 to 200 times as long, has just been announced by Kennametal, Inc. It also provides a longer filing surface, quick and easy blade replacement, and greater handling convenience.

In this new design, the blanks have brazed-on nuts, as shown in the inset on the illustration, and are attached to the light-weight aluminum alloy han



File handle shaped for convenience

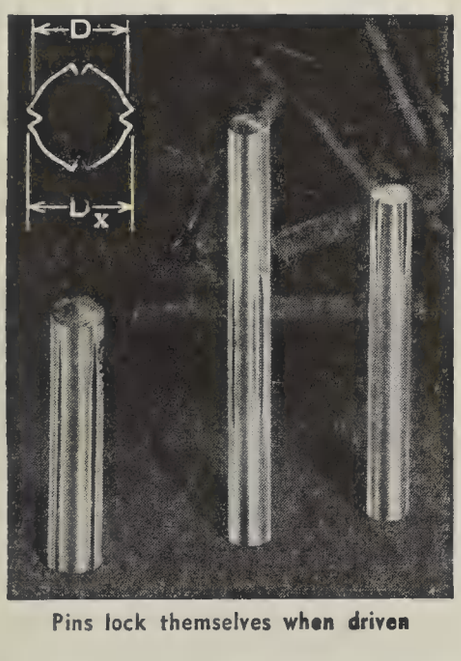
dle by screws. They can therefore be readily replaced when worn from long service. The handle grip is shaped to fit the hand, and has a thumb rest and knuckle guard. An extension beyond the filing surface supplies a convenient finger hold.

SELF-LOCKING PINS

Used to Replace More Expensive Fastenings

STANDARD and special self-anchoring, vibration-proof pins, designed to replace more expensive taper pins, keys, cotter pins, set-screws, rivets, and so on, are pressed or driven into standard drilled holes. These pins have four flutes on the surface parallel to the axis, the length and position of which can be controlled accurately, so that fully or partially grooved pins are available. Fully grooved pins have a pilot at one end so that the pin can be easily inserted.

The raised, work-hardened edges of these flutes provide an expanded diameter of a few (specified) thousandths greater than the nominal diameter of the pin. When the pin is inserted in a drilled hole, these raised edges are compressed inwardly, providing a resilient self-locking element which, it is claimed, will hold indefinitely under vibration or shock conditions. Manufactured by the Driv-Lok Pin Company, they are available in sizes from 3/64 inch to ½ inch diameter, and from 3/16 inch to 4½ inches in length, in any material, and in a wide variety of types.



Pins lock themselves when driven

DIESEL FUEL

Improved by Use Of Additive

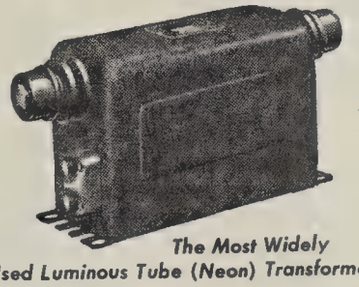
ESPECIALLY prepared as an additive to Diesel fuel oils (four ounces to each 10 gallons of regular Diesel fuel oil), a new concentrate prevents corroding and sticking of injector nozzles and at the same time gives top-cylinder lubrication where ordinary oil fails, thus preventing the formation of hard carbon and sticking rings.

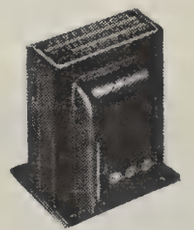
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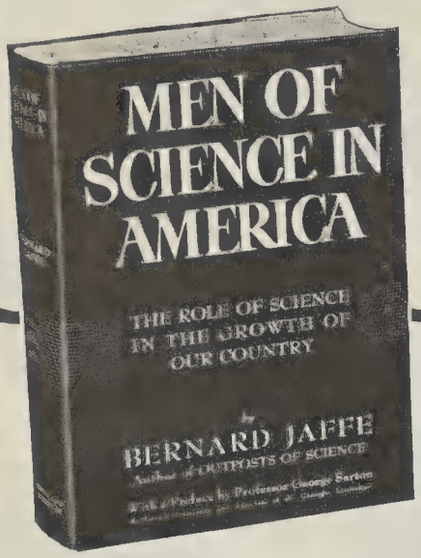

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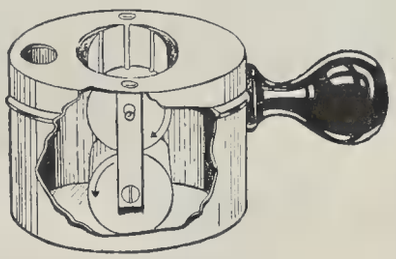
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trate is claimed to give instant overhead lubrication where the ordinary oil system does not reach. It penetrates the pores of the metal and, in addition to giving proper lubrication, prevents hard carbon from adhering to the metal surface. Any carbon which is formed will be soft, and because the metal pores are impregnated with oil capable of withstanding high temperatures, the carbon will be expelled from the engine through the ports.

MARKING POT

Is Economical of Stencil Ink

CONSTRUCTED with two rotating wooden rollers which convey the liquid marking ink from the bottom of the closed metal container to the top roller and then to the stencil brush, a new marking pot is economical of ink. All the ink in the pot is used and, because there are two rollers which automatically stir the ink to prevent settling, there is no pigment accumulation on the bottom and no thickening of the residue of ink left in the pot.



Rollers convey marking ink

Ink capacity is 12 ounces. The cover has the two roller assembly attached to it. This is easily removable for filling and cleaning.

GLOVES

Protect Hands of Industrial Workers

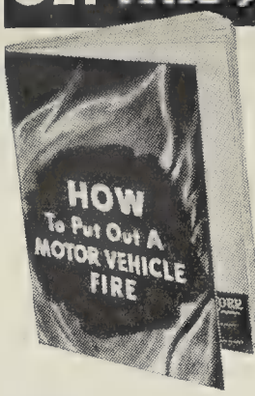
HIGH temperatures and humidity greatly increase susceptibility to industrial dermatitis and call for the constant wearing of protective clothing. To protect the hands from irritating solvents, Resistoflex Corporation has developed a transparent glove made of compar, a vinyl resin derivative.

These gloves give complete protection



Courtesy Grumman Aircraft Engineering Corp.
Hands protected by plastics gloves

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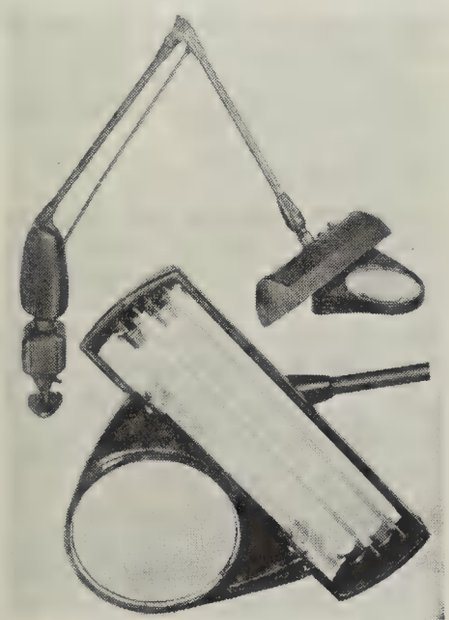
because skin surfaces are prevented from coming in contact with fuels, oils, paints, lacquers, thinners, dry cleaning fluids, degreasing solvents, sulfur-base cutting oils, and so on. Impervious to all organic fluids and many that are inorganic, the gloves are highly abrasion-and-tear resistant. In a wide variety of plants where varsol is used for degreasing metal parts or where kerosine is employed in the Magnaflux inspection process, compar gloves are used to protect the skin.

MAGNIFYING LENSES

Now Built Into Fluorescent Fixtures

AN ADAPTION of "Super Sight" magnifying units to fluorescent lighting has been announced by the Safety Division of The Boyer-Campbell Company. The combination is mounted on a balanced bracket that can be instantly placed in any position.

Where the units are used continuously—in engineering for reading the slide rule, making detailed layouts,



Close-up shows lens and lamps

checking prints, and so on; in the shop, for work over a surface plate; at the bench, for reading verniers and micrometers; for inspection, in checking hardness cracks and similar work—the cool fluorescent lighting adds substantially to the comfort of the operator.

FLUORESCENT HOUSING

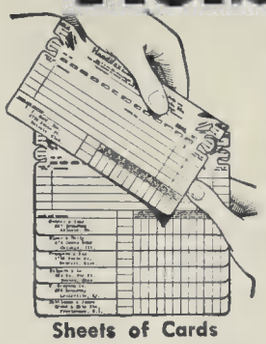
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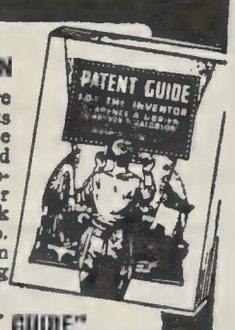
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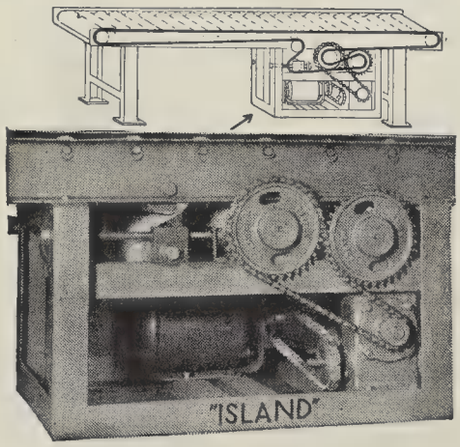
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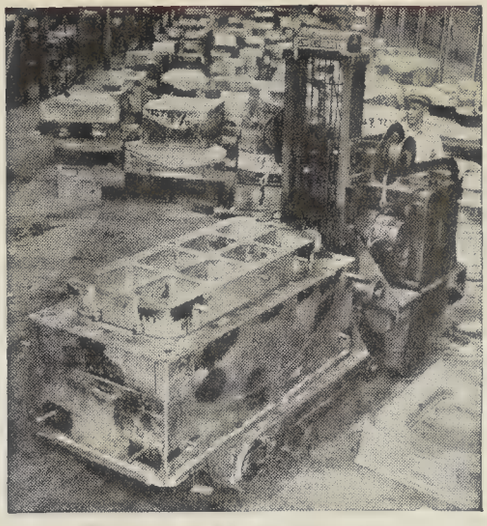
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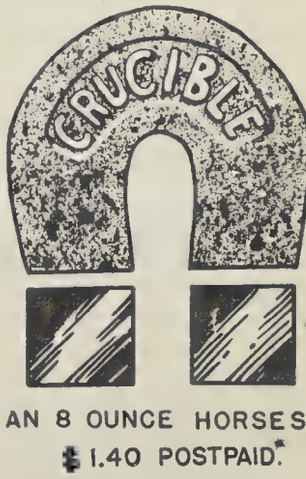


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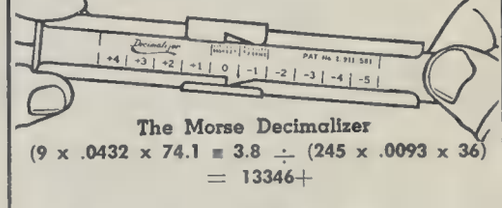
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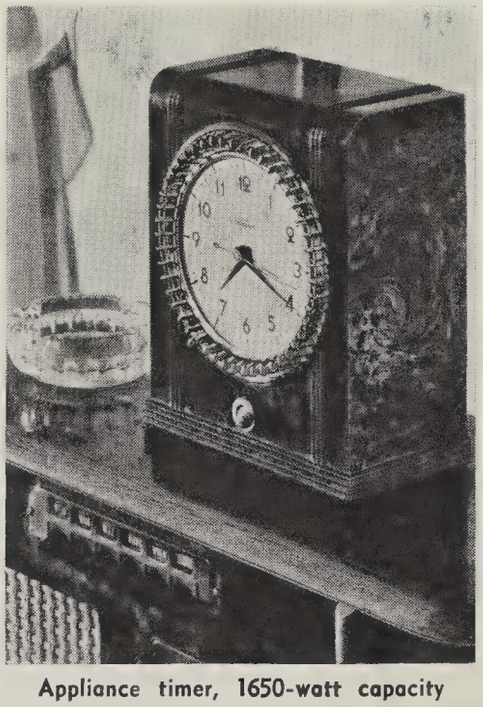
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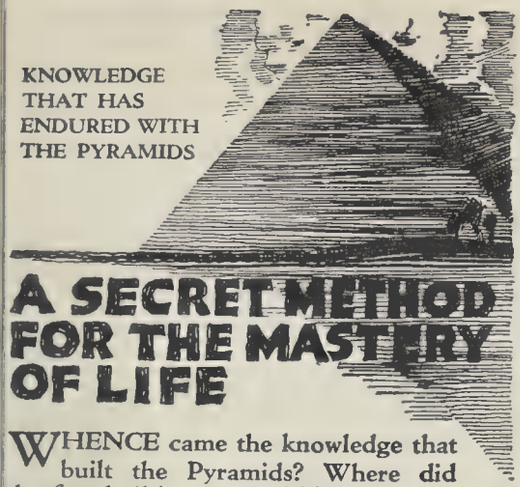
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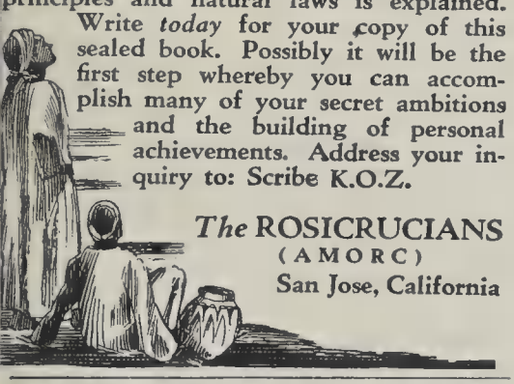
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(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

THE INCENTIVE WAGE is a 24-page booklet based on a survey of incentive wage plans now in use. A three-page introductory summary of the survey is followed by direct quotations of those answering survey questionnaires. In conclusion the principles of wage incentives, set forth by the National Association of Manufacturers, are listed. *The Douglas T. Sterling Company, Research Division, Stamford, Connecticut. —Gratis.*

FEDERAL PRESENTS FM BROADCAST TRANSMITTERS WITH ANTENNAS is a four-page brochure announcing a new line of FM transmitters designed for the new 88 to 106 megacycle band. Technical data, answering questions 18 and 19 of Federal Communications Commission Form Number 319, are supplied. *Federal Telephone and Radio Corporation, Radio Equipment Division, 200 Mt. Pleasant Avenue, Newark 1, New Jersey.—Gratis.*

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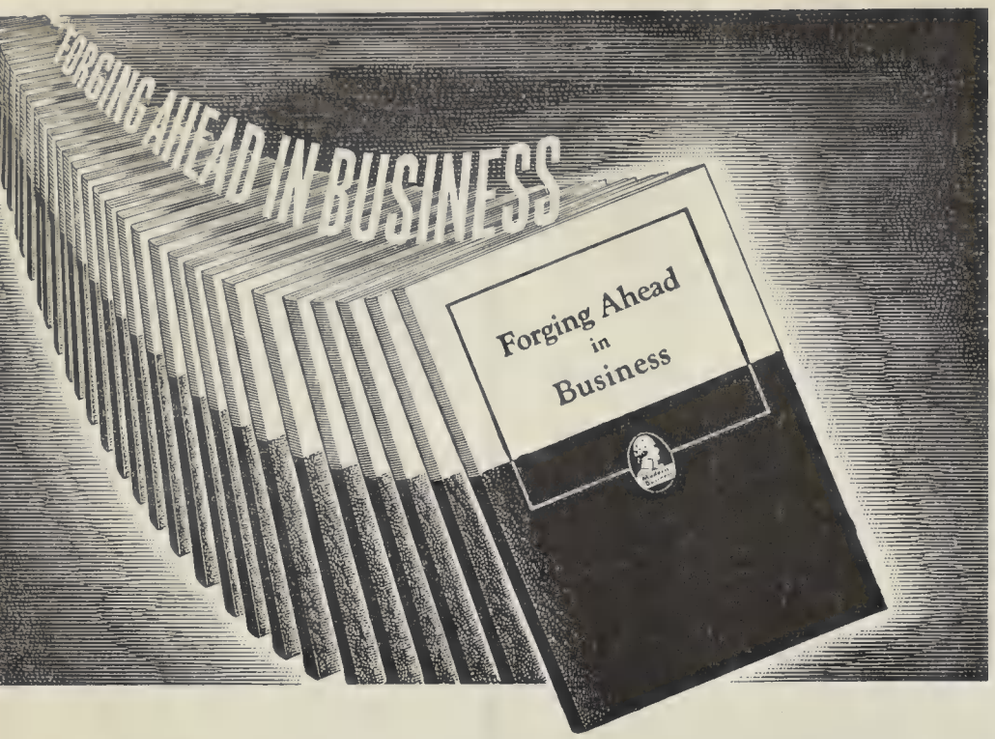
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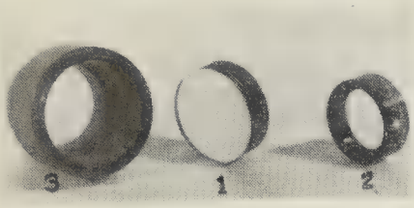
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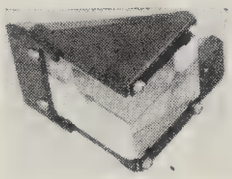


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THE following is the concluding part of the article on mirror making on the hand-lever spindle machine, which was begun last month by Patrick A. Driscoll of the Eastman Kodak Company Hawk-Eye Works.

CLEAN up all traces of 180 emery around the machine, make up a jar (one pint) of 500 emery, and use a new brush. Mike the glass and *write this figure down.* We must grind with 500 emery until we have removed at least 0.008" and until the surface once more exactly fits the gage.

Before proceeding with the 1200 emery, the mirror must be re-miked on its location mark and the reading noted down. To wipe out all No. 500 pits we must remove at least 0.004".

Assuming that the surface is once more a gage fit we now can look forward to polishing, with the assurance that we have a perfect fine-ground surface, free from pits or scratches. A spindle speed of 200 r.p.m. was recommended for grinding. For polishing, we must reduce this to about 36 r.p.m. Any speed within those respective ranges will, of course, prove quite satisfactory. In Figure 1 (in last month's installment) the pulley or gear trains have been left to the builder's discretion, in the belief that many will have their own gear boxes and pulleys and individual initiative for devising ways to change spindle speed.

For polishing, Hindle's machine ("A.T.M.," page 234) will give a close approximation to the action of the machine in Figure 1 and will be quite satisfactory if the worker prefers it. In either case, the spindle should have a speed of about 36 r.p.m. All belting, Hindle or Driscoll, should be double V-belt. The speed reduction from the motor can be accomplished by belting or, in the probable event of financial affluence, by a gear reduction unit. Try the gear shift unit from the family flivver.

Elaboration or addition of automatic stroke is left to the individual's discretion.

To shape the cold polisher to curve we place it and the mirror in a *large* pan of water and *slowly* heat them until the pitch is fairly soft to the touch and the glass is fairly warm to handle. Next, place the hot, wet polisher on the machine, apply thick rouge, start the spindle rotating and form the polisher to curve, using the mirror as a forming instrument.

If the polisher and glass cool down too soon, dunk them back into the pan of water for a while and proceed as before. The pan of water will stay good and warm if you make it big enough. Do not use soap and water as a lubricant.

The rouge will color the polisher as it conforms to the glass, and any black areas may be assumed not to be in contact. But when the lap is a dull red all over it is formed to curve and contact.

To cut the polisher we place it, cold, on the machine and, with the spindle rotating, hold the corner of a single-edged razor blade against it and scrape, not cut, grooves into it, spaced about ⅜" apart and 1/16" deep. They need not be wide nor deep. I have found nothing better than the single-edged razor blade for cutting the polisher, not because of its cutting edge but for its sharp corner when used as a scraping device.

During the forming of the polisher and in all polishing it *is most important that the grooves in the polisher or lap be kept open.* They do not have to be deep or wide.

On a concave surface a polisher having the same diameter as the work will have a tendency continually to shorten the radius of curvature; that is, it will "drive the center low," polishing the center more than the edge. Therefore a hyperbola develops, even with a rational stroke. In trying, then, to lengthen the radius and get out of his hyperbola, the worker resorts to a very short stroke; and thus, by polishing the edge much more than the center, he lengthens its radius and winds up with two foci, a short center and a longer (turned) edge. The turned edge is caused by trying to correct the tendency of the shortening effect on the radius.

Thus, three fourths of the polishing time is lost in trying to keep the focal length up to standard and, in so doing, three fourths of the abrasive effect of the polisher is put on the edge of the mirror. This is one of the causes of that great bugaboo, turned edge.

By inverting polisher and mirror the worker can reverse the action of his equal diameter polisher but, while the polisher when on the bottom unduly hits the center because it is too small, so does the polisher when on top unduly hit the edge because it is too big—and in both cases much too hard. Thus we have the dilemma: either the turned edge or hyperbola. Of course, by juggling the polisher and glass, and by using all sorts of strokes, a spherical surface is finally attained—if our judgment, timing, and patience are working overtime.

A convex surface with equi-diameter polisher on top will be hardest hit on the edge (and once again a shortened radius). The equi-diameter method holds the worker to a short stroke, less abrasive or polishing action, and greatly increased polishing time.

Proceeding once more on the assumption of a concave surface to be polished we place the six-fifths diameter polisher on the spindle, lay the mirror face down on it, adjust the stroke neither long nor short but medium, and give the work a 15-minute polishing spell.

The rouge should be of a creamy consistency. Keep it in a jar and apply it with a soft ½" brush.

The center of the mirror should cross center of polisher at every stroke.

For a 6" mirror a pressure of about eight pounds will suffice. A fair rule for weight on the drive-pin of the stroke arm (which has a slip fit so that the weight of the worker's arm, itself is not transmitted to the work) is 1½ pounds per inch of diameter.

Remove the work and measure the radius by the Foucault test. Use a ¼" pinhole covered with window screening, and substitute a piece of fine ground glass for the knife-edge, the two mounted so as to move as a unit together. When the image of the squares of screening is sharpest on the ground glass (scan with a 1" f. l. magnifier) we have ascertained the radius of curvature, and half this distance is the f. l. of the surface within 1 mm.

If the radius is too long, the center of the mirror must be polished more than the edge. Therefore, increase the length of the stroke. If the radius is too short the stroke must be shortened to polish the edge more than the center.

By testing often, the action and effects of the machine will become more and more familiar as we proceed.

Thus far the radius of curvature has been referred to as too long or too short. In optics a concave surface is often referred to as "high" (long radius) or "low" (short radius), and hereafter we shall use these terms.

If the low surface is fitted to the gage it will show space under the center, because the curve is too deep. The high surface will show space under the edges because the curve is too flat.

Let the polishing spells be about 15 minutes in length. When approaching the desired radius of curvature, shorten these spells and test often.

Ring grooving of the polisher affords an additional correction to obstinate zones. An example: The curve is too low (deep) and short strokes do not seem to change the radius during a few polishing spells. Therefore, from the center to half way out on the polisher we scrape additional grooves between each present groove. Conversely, if the surface is high we scrape more grooves on the polisher's outer area.

A warning: Do not make these corrective grooves too deep. Be easy with pressure on the razor blade scraper. The grooves are to correct a temporary fault only, and when this has been accomplished we do not want them to continue their effect. Regroove them lightly and often but only as long as they are needed. If, however, the should remain after the surface is corrected, scrape balancing grooves on the remainder of the polisher, to nullify their effect and from now on let the intermediate grooves close up but

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Harvard Observatory, Cambridge 38, Mass.

not fail to keep the regular grooves open at all times. Never let them close.

A corrective method, alternative to local grooving, is to scrape the center or edge with the razor blade held square on. Scrape ever so lightly, my friend, ever so lightly. Even with this warning some probably will scrape too much and get into trouble.

If a slight stain appears on the mirror, a 15-minute spell using plain water and no rouge will usually remove it. If not, add about ½ teaspoonful of vinegar to ½ pint of rouge.

It is not necessary to remove the work every time the tool needs recharging. In applying emery or rouge use a brush and apply while the machine is running.

Since all the foregoing has treated the concave surface for the benefit of the mirror maker, we must now make amends to the refractor builder and not leave him high and dry. Let us bring him down to our lowly level and carry this discussion into the field of convex surfaces.

Our rule calls for the convex surface to be ground and polished face up, tool on top. The grinder will be 4/5, and the polisher 5/6, the diameter of the lens.

In reversing the position of the lens from the top to the bottom we also reverse the action of the stroke for correcting high or low test findings. The high concave would require a long stroke. The high convex would require a short stroke. The low concave would need a short stroke. The low convex would need a long stroke. In sum, on a concave surface, when the curvature is not deep enough it is high. When the curvature is too great, it is low. On a convex surface the conditions are directly opposite. The polishing technique for a convex surface is different from that of the concave only in the inversion of the lap and action of the stroke.

A last and oft-repeated warning: Do not attempt to polish until the surface exactly fits the gage after fine grinding. We do not wish to polish ourselves into an early grave.

Finally, I extend my condolences, in the form of a more simplified polishing machine, to the amateurs who lack the material, space, and so on, for a better one. This machine will do everything the one already described will do, except that the time factor will be extended considerably. The spindle should be vertical, running at about 36 r.p.m., and the stroke arm should be double, consisting of your own two strong arms with sleeves rolled up. Merely place the work in a chuck (Figure 3, insert, last month), and apply your strokes exactly as if you were a part of the machine. The chuck for hand polishing may be made of metal or wood, and lined with glued-in felt. The drive pin notch shown on its top is not for hand work, but with it this same chuck may, if preferred, be substituted for the metal button of Figure 1, in polishing.

After each 15 or so strokes, let go of the chuck. The work will revolve with the spindle. After about three seconds, drop the hands back on the chuck and proceed. Do not be afraid of the work flying off the spindle when you let go; it won't, since 36 r.p.m. is not fast enough to cause alarm on this score.

With this machine no single condition or relation of work to polisher will be duplicated, and neither monad, astigmatism, nor one-sided test (one area of different radius) will occur.

It is my humble opinion that amateur optics can well afford to get away from some of the do's and don'ts prescribed by workers in the past, not omitting the wearing of round-the-barrel ruts in the rug. So roll out the barrels.

End of Driscoll's contribution.

READERS are warned that the 200 r.p.m. recommended in the above articles should not be carelessly exceeded. "Faster, disaster," is Driscoll's warning, in a private communication, while Leo J. Scanlon of Pittsburgh, who has used a hand lever machine, is of the same mind and urges not falling asleep even at 200 r.p.m. Especially is this pertinent in the final stages of grinding, since at this stage the grinding surfaces become dry or warm and seizure may take place so quickly as to end possibly in the disaster against which Driscoll warns. Henry Paul, Norwich, N. Y., also has used a hand lever machine and protects his mid-section by embodying a heavy steel splash pan in his equipment; an added piece of plank would serve the same purpose. In the next number an illustrated description of Paul's hand-lever machine will be published, with numerous sidelights on its operation.

GLEANED while reading a back number of the *Journal of Scientific Instruments* (London, February, 1938, p. 3) is the following fragment abstracted from a paper on "The Mechanical Amplification of Small Displacements," by Professor A. F. C. Pollard, and of probable interest to Carborundum-conscious readers.

Place a well-made agate knife-edge from a micro-chemical balance in contact with a microscope cover-glass under a high power of the microscope, in monochromatic light. Note fringes from the two facets, also black areas surrounded with very irregular contours from the edge.

"One wonders," Prof. Pollard remarks, "how it is that agate knife-edges function as well as they do."

Now select a perfect Carborundum crystal about ⅛" long and similarly test it. Though the crystal edge included by the facets is at an angle of about 117°, this edge is almost perfect and is seen as a black fringe along its whole length. Such perfect crystal edges should form ideal knife-edges for highly sensitive and delicate lever systems, Professor Pollard states, "but I know of no case in which the crystals have been used for this purpose." But he adds that Professors McBain and Tanner have used two sharp points of Carborundum crystals to function as the knife-edge of their highly sensitive microbalance, and with great success.

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Whispered Words I Thought I'd Never Hear . . .



November 3 . . . Tonight, John asked me to marry him! And only a few months ago I thought I'd never hear those precious whispered words I've dreamed of all my life.

Little Book, you know what I mean. Into your pages I've poured the hurt, the longing, the loneliness that was mine because of my poor hearing.

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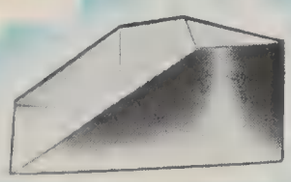
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THE ADVOCATE OF INDUSTRY AND ENTERPRISE, AND JOURNAL OF MECHANICAL AND OTHER IMPROVEMENTS.

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THE
SCIENTIFIC AMERICAN,
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(THE PRINCIPAL OFFICE BEING IN NEW YORK,)
By RUFUS PORTER.

Each number will be furnished with from two to five original Engravings, many of them elegant, and illustrative of *New Inventions, Scientific Principles, and Curious Works*; and will contain, in addition to the most interesting news of passing events, general notices of the progress of Mechanical and other *Scientific Improvements*; American and Foreign Improvements and Inventions; Catalogues of American Patents; Scientific Essays, illustrative of the principles of the sciences of Mechanics, Chemistry and Architecture; useful information and instruction in various Arts and Trades; Curious Philosophical Experiments; Miscellaneous Intelligence, Music and Poetry.

This paper is especially entitled to the patronage of Mechanics and Manufacturers, being the only paper in America, devoted to the interests of those classes; but is particularly useful to farmers, as it will not only apprise them of improvements in agricultural implements, but instruct them in various mechanical truths, and guard them against impositions. As a family newspaper, it will convey more useful intelligence to children and young people, than ten times its cost in school instruction. Another important argument in favour of this paper, is that it will be worth two dollars at the end of the year when the volume is complete, (Old volumes of the New York Mechanic, being now worth double the original cost, in cash.)

TERMS.—The "Scientific American" will be furnished to subscribers at $2,00 per annum,—one dollar in advance, and the balance at six months.

Five copies will be sent to one address six months, for four dollars in advance.

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Wife, Children and Friends.

If the stock of our bliss be in stranger hands vested,
The fund, ill secured, oft in bankruptcy ends;
But the heart knows bliss which are never protested.
When drawn on the firm of—wife, children and friends.

Though valour still glows in life's dying embers,
The death-wounded tar, who his colours defends,
Drops a tear of regret as he, dying, remembers
How blest was his home with—wife, children and friends.

The soldier, whose deeds live immortal in story,
Whom duty to far distant latitude sends,
With transports would barter whole ages of glory
For one happy day with—wife, children, and friends.

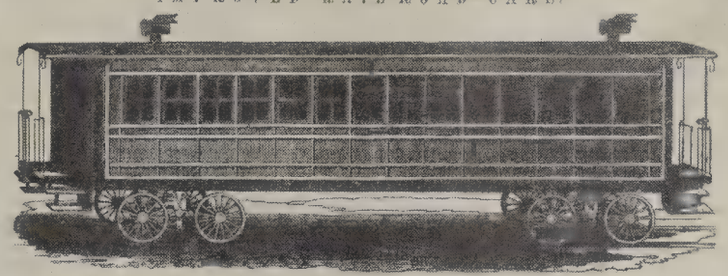
The day-spring of youth, still unclouded by sorrow,
Alone on itself for enjoyment depends;
But dearer is the twilight of age, if it borrow
No warmth from the smile of—wife, children, and friends.

Let the breath of ——— ever feebler and nourish
The laurel which o'er the dead favourite bends,
Ere me wave the willow, and long may it flourish,
Bedewed with the tears of—wife, children, and friends!

Attraction.

Attraction is a curious power.

IMPROVED RAIL-ROAD CARS.



There is, perhaps, ——— mechanical subject, in which improvement has advanced ——— rapidly, within the last ten years, as that of railroad passenger ———. Let any person contrast the awkward and unsouth cars of '35 with the superbly splendid long cars now running ——— several of the lines of roads, and he will find it difficult to convey to a third party, a correct idea of the vast extent of improvement. Some of the most elegant cars of this class, and which are of ——— capacity to accommodate from sixty to eighty passengers, and run with a steadiness hardly equalled by a steamboat in still water, are manufactured by Davenport & Bridges, at their establishment in Cambridgeport, Mass. The manufacturers have recently introduced a variety of excellent improvements in the construction of trucks, springs, and connections, which are calculated ——— avoid atmospheric resistance, secure safety and convenience, and contribute ——— and comfort to passengers, while flying ——— the rate of 30 or 40 miles per hour. We purpose to give a particular description of these improvements, accompanied with suitable engravings, in our next number, that our readers may be enabled to appreciate more fully the progress of improvements in this important branch of mechanism.

LOWELL AS IT WAS AND AS IT IS.—By Rev. HENRY A. MILES, is a neat 18mo of 294 pages just issued by Powers & Bagley, Lowell. It is full of facts of general interest. We learn from it that the Merrimac Company (whose dividends are so often quoted) employs 1250 women, whose average earnings considerably exceed $2 each per week above the cost of their board. The laboring ——— average 85 cents per day above their board; fifty-six overseers receive ——— each per day with occasional premiums. [These are the *resolved* wages we have so.] Nine are employed under fifteen years of age. No woman is retained a day after she is known to be guilty of licentious conduct, but not one in a hundred is ever discharged for any such cause. The average running time is 12 hours 10 minutes per day, which is ——— long and should be shortened, but the average working time of each hand is but ten hours and a half. In the Boott Mills, a careful account of working time has been kept, and it appears that 196 girls averaged 287 days each in a year and 10 hours 8 minutes per day, each being paid according to her work, and 1.2⁰ all are paid in cash every month,—not one farthing in store orders, or barter of any kind. The average earnings of the women in all the factories, including *services*, is $1.93 per week besides their board. Many girls who have been school teachers gladly take places in the mills, as the pay is higher here, and the work lighter, though the hours ——— longer. No one has lost a sixpence of her earnings in the Lowell factories since the first ——— rted. The girls have about $100,000 in the Savings Bank.

—Such is the condition of the Laboring Class in the principal Manufacturing town in America. Granted that it is not all it should be—that it might ——— should be improved—it is still true that no where else does a Laboring class of equal numbers earn so much, year by year; no where else are they so constantly employed, comfortably situated and

BURNING WELL.—A correspondent of the Cleveland Plain Dealer, gives an account of a burning well that may be seen at Southington Centre, in Trumbull county, Ohio. The well is 91 feet deep, all but 24 feet through sand-stone, quick-sand and hard rock, which the augur used for boring could not penetrate. When it was withdrawn, a peculiar odor, accompanied by a rushing sound, was perceived. Suspecting the presence of inflammable gas, Mr. Wannemaker, the owner of the well, lowered a lamp into it. A violent explosion, that did some injury to the bystanders, was the consequence, and the gas still continues to burn. It is doubtless carbureted hydrogen.

NEW ARTICLE ——— EXPORT.—We are ——— that a Yankee broom maker in Ohio has leased some twelve hundred acres of bottom land, on the Scioto river, near Columbus, and planted the entire plot in broom corn, with a view to export the crop to England, where he intends to proceed himself, and engage extensively in the ———facturing of brooms, taking with him the wood for the handles, and the machinery used for the purpose. Brooms made from the American broom corn ——— much superior, for various uses, to any thing to be had in England, that they have become, within a few years past, quite a favorite in that country and are ——— exported thither in large quantities.—*Ex paper.*

EXTRAORDINARY FERMENTATION.—The inhabitants of the village of Moulton were greatly astonished on Saturday last, at observing a considerable quantity of hay (from a field where it was in cocks for stacking) rise rapidly into ——— air. There was not the slightest breeze of wind perceptible ——— the time—hower or the hay continued to ascend until it apparently passed through the clouds, which were sailing high at the time. After the mass of hay

GREAT IMPROVEMENT IN LITHOGRAPHIC PRINTING.—A very important improvement has been made in the lithographic printing machine by a young French engineer named Nicolle, by which the same precision and regularity of pressure is obtained as by the common hand-press. By the common lithographic process, not more than from 200 to 250 good impressions of designs, or about 1,000 copies of lithographic writing, can be obtained in twelve hours; by ——— new machine, which is also worked by hand, as many as 2,000 of the former, and 20,000 of the latter, can be obtained within the same period of time.

A SENSIBLE ———HORSE.—One of the truck horses of Mr. Hinds was unloosed for a minute or two, ——— the trucks, a few days since, in this city, when, on the driver looking around for him, behold he was missing. It was an hour or two, before the driver could discover his whereabout. It was very mysterious, he being a steady beast, and not subject to flights of fancy. However, he was ——— last found in the smith's shop, where he was wont to have ——— shoes repaired. The ——— said ——— horse entered and took the usual stand for shoeing. Upon examining his feet he found one shoe off, which ——— supplied. That horse is a sensible beast.

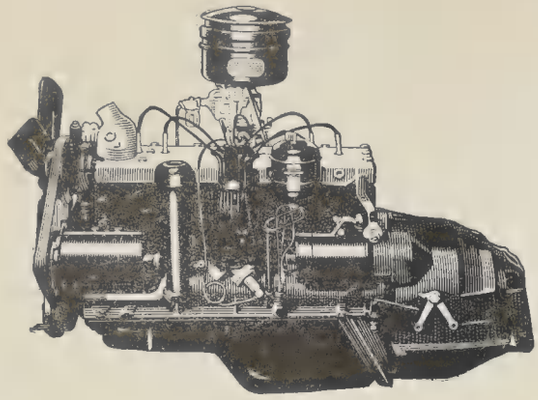
THE PROPERTIES OF ZINC.—Professor Faraday, ——— we are informed in the London Athenæum, has made this metal the subject of many interesting experiments. He has discovered that it ——— new properties ——— being melted ——— poured into water, the metal becoming very malleable and soft, losing none of its tenacity, but still capable of being spun into the finest wire, pressed into any required form, ——— rolled into any thinness desired. This promises to be a very useful discovery.

CATALOGUE OF AMERICAN PATENTS
ISSUED IN 1844.

CLASS I.—*Agriculture, including Instruments and Operations.*

Bee Hives—Improvement in Bee Hives by Aaron E. James, Point Pleasant, Va., Jan. 6th.
Do. Samuel & J. D. Cope, Damascusville, Ohio, Feb. 8th.
Do. George B. West, Fairfield, Ohio, April 26th.
Do. James A. Cutting, Haverhill, N. H. June 24th.
Do. Jacob D. Fulkerson, Unity, Ohio, July 1st.
Do. Oliver Reynolds, Webster, N. Y., Dec. 4th.
Bee Palaces, Lemon Hamlin, Kirkersville, Ohio, July 13th.
Improvement in Churns—George W. Cook, St. Louis, Mo., Feb. 28th.
Do. Harmess Bently, Ballston, N. Y., April 26th.
Do. Jason B. Schermerhorn, New York, June 5th.
Do. Thomas Ling, Portland, Me., Aug. 21st.
Corn and Cane Cutters—Jacob Peck, Oakland, Penn., Aug. 28th.
Corn Fodder, Cutting and Crushing—Rudolph Miller, York, Penn., Oct. 3d.
Cane-Shelter—William McAll, Talladega, Indiana, April 13th.
Cultivator—Robert Nelson, West Point, Ia., Jan. 15th.
Cultivator—William Dycert, Gettysburg, Penn., Aug. 16th.
Cultivator Tooth—James ——— Marshall, Hamorton, Penn., Nov. 9th.
Fruit-gatherer—Alexander McWilliams, Washington, D. C. March 13th.
Harrow, sward-cutting—Dennis Rice, Rowe, Mass., May 17th.
Hulling Clover Machines—A. B. Crawford, Worcester, Ohio, Dec. 31st.
Hulling ——— Pearling Rice—Jacob Grout, Troy, N. Y., July 11th.
Mowing, Grain Cradles—William A. Wood and John C. Loveland, Hoosick Falls, N. Y., Nov. 12th.
Mowing, Harvesting Machines—George Esterly, Heart Prairie, W. T., Oct. 22d.
Mowing, Hemp Cradles—Griffin Reynolds, jun. Washington, Ky., May 20th.
Mowing, Reaping Machines—William P. Ketchum, Buffalo, N. Y., Nov. 18th.
Improvement in Ploughs—John Thompson, Ripley, Ohio, April 17th.
Do. Aaron Smith, Bloomfield, Mich., May 6th.
Do. Jonathan Moores, Hazelton, Penn, July 1st.
Do. Anthony Taylor, New Garden, Ohio, Dec. 19th.
Plough, adjusting—William R. Allan, Brownsville, Ky., Jan. 31st.
Plough, combined—Harvey Crowe, Payson, Ill., March 9th.
Plough, double—Aaron Smith, Bloomfield, Mich. May 16th.
Plough, excavating ditches—James Herbert, Lagrange, Ia., April 13th.
Plough, gathering weeds under the furrow slice—Dudley Hills, East Hartford, Ct. Oct. 7th.
Plough, wheel—Israel Long, Bucyrus, Ohio, March 9th.
Potato-Diggers—Archibald C. Keechum, Schenectady, N. Y., Feb. 20th.
Rake, grain—Benoni F. Partridge, Onondaga, N. Y., March 13th
Rations ——— Cane Cutters—Robert Lauve, Plaquamines, La., Sept. 17th.
Seeding, corn planters—Thomas R. Hoskings, Crawfordsville, Ia. Jan. 30th.

Anniversary Issue No. 12









HOW MANY ENGINES ARE THERE IN YOUR LIFE?

LET'S SEE—there's the engine in your car. That's one. But don't answer the question too quickly; you may be overlooking dozens of other important engines.

For example, when you came down to breakfast this morning you found a bottle of milk that had just been delivered in a milk "wagon" hauled by an engine instead of a horse. Your rolls, eggs and coffee, too, came at least part way by truck. And the breakfast food you ate was probably grown with the aid of a gasoline-engined tractor.

There's a good chance you came to work on a bus. That's another big engine to remember. The airmail letter waiting for you on your desk got there with the help of two—maybe four—powerful aviation engines. And sometime during the day a motor truck will roll up to your door with materials for you, while perhaps another one is delivering your products to your customers.

We could go on and on—but by now you've realized there is scarcely a thing you eat, drink, read, wash yourself with, make, buy or sell that isn't manufactured or transported with the help of gasoline engines. In fact, your life is full of engines. Doesn't it follow that when these engines are made more efficient, more powerful, more economical, more durable, you will benefit?

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Our Cover: Page 1 of Volume 1, Number 1, Scientific American, greatly reduced in size, forms a fitting subject for this month's cover illustration. A running history of the development of Scientific American—from 1845 on—will be found in the article starting on page 327.

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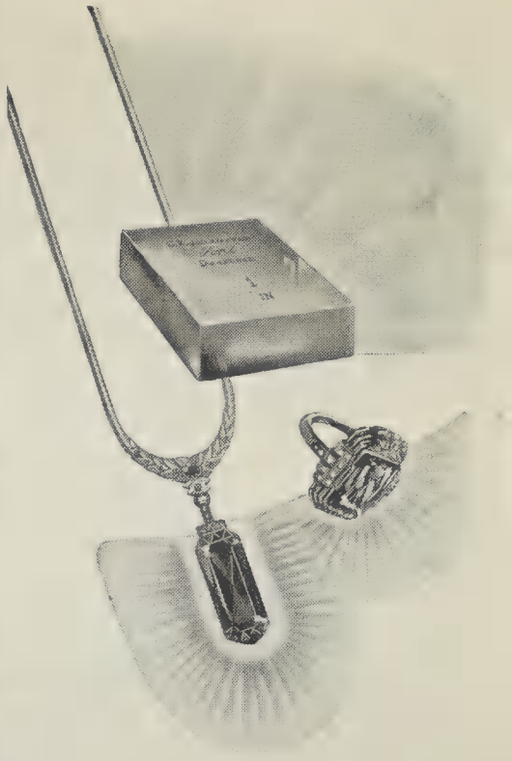
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Previews of the Industrial Horizon

By A. P. Peck

ATOMIC POWER

NOW THAT the first burst of enthusiasm—misguided and otherwise—regarding atomic power has simmered down somewnat, it seems appropriate to scan briefly some well-founded opinions on the subject.

At a recent meeting of the American Society of Mechanical Engineers, members of the Gas Turbine Coördinating Committee rendered a preliminary report on atomic power. Looking upon atomic energy as an addition to the world's supply of fuel, the committee goes on record as saying: "It is felt that atomic power certainly will not replace present fuels but will supplement them, as oil supplements coal." They look forward to the possibility of power-plant units "above 200,000 kilowatts, wherein both the gas and steam turbine are utilized in the same plant, using both present fuel and atomic power to achive the greatest efficiency."

Because the heat evolved in atomic fission offers an intriguing lure to the power engineer, the Gas Turbine Committee warns: "Possibility exists also that radio-active by-products of the atom-splitting process might make the air unusable in a gas turbine. It appears from this consideration that a semi-closed cycle might be preferred, using the heat created but eliminating the radio-active by-products from the gas turbine."

All informed sources stress two important aspects of atomic power: Cost of material and time of development. Cost will undoubtedly be extremely high for years to come, and the necessary development work will pursue a long and arduous path. Thus, to central power stations, railroads, and other businesses in which the generation or use of power is of extreme importance, General Electric engineers put it this way: "Were we responsible for conducting the affairs of such organizations, we would go right ahead with our plans for the years to come on the basis of present-day commercially available sources of energy: namely, coal, oil, and water power. Only as research and development proceed shall we learn the limitations and possible practical commercial applications of nuclear power."

PATENTS AND SMALL BUSINESSES

STATING that "the Patent System functions as the indispensable stimulant to that competitive enterprise upon which the continued progress and security of America depends," the National Patent Council has been organized to represent smaller manufacturers in the defense of the United States Patent System. The Council, controlled by the smaller manufacturers, will appeal directly to fair-minded Americans to prevent misled "reformers" of the patent system from promoting monopoly by making changes in our patent laws which would threaten the life of every smaller company relying for its existence upon patent protection.

FURNITURE FINISH

AN ENTIRELY new finishing system for wood looms on the horizon and promises a better, faster, more economical method of operation for all wood furniture plants.

In the past, the accepted method of finishing fine furniture involved the use of a number of coats of comparatively slow-drying varnish. Each coat was carefully sanded by hand and given its final polish by the same method. Then came the fast-drying lacquers that cut finishing time from weeks to a matter of days, but still required polishing to bring out the grain of the wood. But—and here was the catch—a finish that could successfully be sanded could not be hard, tough, and elastic; and hardness, toughness, and elasticity are greatly to be desired in furniture finishes.

Now comes the new Durez process, in which neither varnish nor lacquer is used. Rather, the protective film is a pure resin of the type found in phenolic molding compounds. However, it does not have to be applied in sheet form but can be sprayed like an ordinary lacquer and cured in a matter of minutes, using infra-red. The resulting film is tough and hard, and resistant to water, mild acids, alkalies, and abrasive compounds. Best of all, from an industrial standpoint, it makes possible the development of a beautiful finish on a piece of wooden furniture within three or four hours after the parts have been assembled.

FUNNY FUZES AND RADIOS

RADIO engineers see great commercial possibilities in the extended use of the equipment that made possible the radio proximity fuze. This device, dubbed the "funny fuze," causes rockets, bombs, and other projectiles to burst when within a predetermined radius of the target. Heart of the funny fuze is a set-up of five vacuum tubes housed in a space smaller than that encompassed by a tea-cup. The fuze operates on radar principles but its greatest implication at the moment is for the development of pocket-size radio sets and extremely compact electronic equipment for many industrial control and indicating purposes.

TELEVISION COST

PRICES of television receivers are subject to serious discussion these days. And here's what to expect in the near and medium-near future: For $100 there will be sets giving a picture of about post-card size, suitable for two or three persons to view; for $250 to $300 it will be possible to buy a receiver that will give a picture which eight or ten persons, sitting an average of ten feet from the screen, can enjoy; if projection on a screen is wanted, so that a whole roomful of people can be entertained, expect prices upward of $1000 or more. Its all a case of getting what you pay for. The television field surely will have its Fords and its Cadillacs; and now as always, more people ride in Fords than in Cadillacs.

WOOD WASTE MAKES WOOD

A HARD wallboard made from sawdust, by a process so simple that it can be applied even by small saw-mill operators, holds promise of solving many of the problems of our diminishing wood supply. Production of the new grainless board has been likened to the housewife's use of prepared cake flour—add water, stir, and bake.

Secret of the process is the use of chemical catalysts themselves made from wood. Reports so far indicate that the entire procedure, from sawdust through mixing and pressing, takes less than 15 minutes to the finished board.

FOR FUTURE REFERENCE

AUTOMOBILES, says an aluminum authority, should weigh 1000 pounds and up, instead of the present 3000 pounds and up. . . Those concerned with the development of aviation—both commercial and private—should give serious consideration to the development of more sightly airports. . . Color, bright and durable color, has great industrial significance; buyers of everything from tooth-brushes to tractors are more color conscious than ever before. . . Ceramics, resistant to intense heat, will in part replace metals in tomorrow's gas turbines.

So you'll see better

Nature designed your eyes for seeing by daylight. *But the average person spends most of his waking hours under artificial light.*

To develop *better* artificial light —for all living and working conditions—has been a continuous project of G-E engineers and research scientists. They have even developed a whole new Science of Seeing.

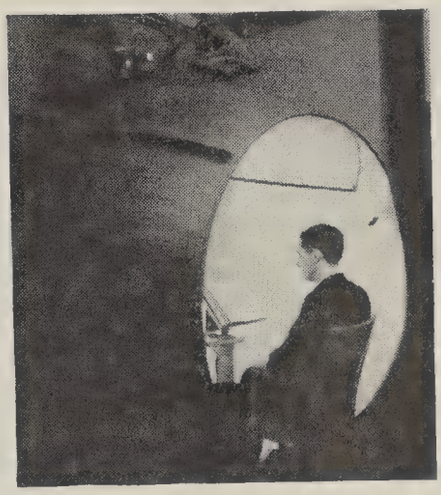
The pictures on this page illustrate a few ways in which G. E. is helping you see the day-by-day and night-to-night things more easily. *General Electric Company, Schenectady, N. Y.*



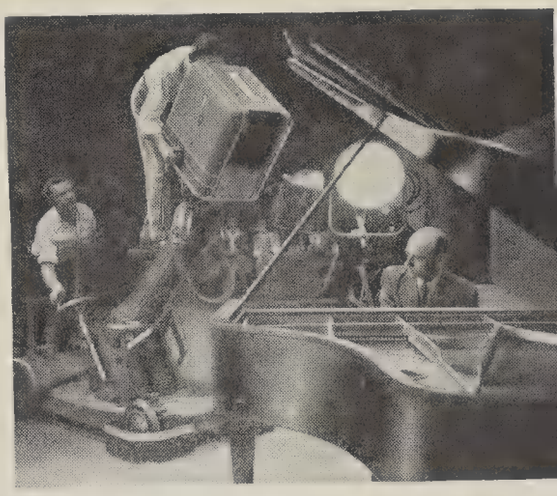
Powdered Light. This luminous powder that you see is a *phosphor*. Coating the inside of every G-E fluorescent lamp, it transforms invisible rays into soft, cool light. Recently General Electric developed a remarkable *new* phosphor which will be used in a new fluorescent sun lamp to provide healthful summer sunshine all year round, economically and efficiently. And speaking of economy, G-E lamp research has reduced the cost of a 60-watt G-E bulb by 75% since 1923. Another way in which General Electric helps to bring More Goods to More People at Less Cost.



The tiny 7-watt G-E bulb in this night light makes darkened halls safely navigable for sleepy people. It's especially useful in homes with small children. And the cost of electric current has been brought so low that, at average residential rates, this little lamp will burn for four 8-hour nights for only a penny or so!



What's the best light for reading? Above is one of many testing devices in the G-E Lighting Research Laboratory. The amount of light on the page and the amount of general illumination inside the sphere are varied to determine best seeing conditions.



You'll soon see important events as they happen —by improved television with a bigger screen and clearer reception. Back in 1928 a G-E engineer, Dr. E. F. W. Alexanderson, gave the first public television demonstration. And for more than five years now, G. E. has been telecasting regular programs from its own station, WRGB.

The best investment in the world is in your country's future

KEEP ALL THE BONDS YOU BUY

GENERAL ELECTRIC

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of December, 1895)

TELEPHONES — "Chicago police now have a telephone and signal system, consisting of 887 public and 370 private boxes, operating on 81 circuits, connected with the 37 precinct stations of this department, in which they are located. The system includes public sentry boxes placed at street intersections, equipped with a signal box to transmit the number of the station; a telephone for patrolmen to report and receive orders over; a chemical register at the station which records the calls, and the necessary switches for operating the telephone and testing for electrical disturbances."

ELECTRIC MOTORS — "On January 1, 1895, the Edison Electric Illuminating Company had connected 7,615 horse power of electric motors, but at the end of October it had no less than 11,263 horse power, an increase of 3,648 horse power in the short period of ten months. . . The company has 251,487 incandescent lamps connected and 3,280 arcs. This would figure out in the neighborhood of 25,000 horse power, so that one-third of the company's total connected capacity is now represented by motors. . . It is evident that the stationary motor industry must be increasing at a rapid rate, for these figures, large as they are, take no account of other stations than the Edison and do not include isolated plants."

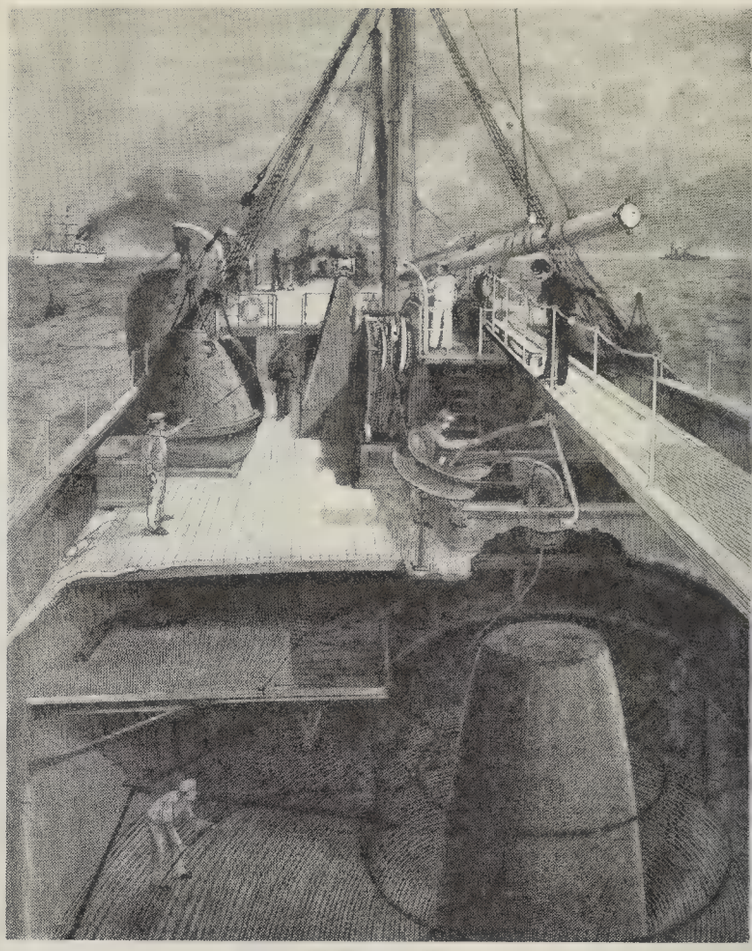
WINDMILLS — "In this country the windmill has of late years been greatly improved and brought extensively into use. It is estimated there are over half a million windmills now running, and the annual increase in sales is estimated to be upward of 50,000. They are mainly used for pumping the domestic water supply; in many of the Western States a farm is scarcely considered to be complete unless it can boast of its windmill pump."

FIREFIGHTING — "At a recent fire the Chicago firemen demonstrated at the Masonic Temple their ability to cope with fires in the upper stories of the tallest buildings. Engine No. 1 of the city fire department pumped a stream of water through 500 feet of hose and standpipes to the roof of the building, where there was sufficient force to drench the roofs of neighboring buildings. The water pressure at the engine was 240 pounds. On the roof at the same time the pressure was 54 pounds to the inch."

PROPELLER SHAFTS — "It is getting to be pretty well understood that the frequent breaking of propeller shafts is not due to the defective material of the shafts themselves so much as to the excessive strains to which they are subjected, owing to the working and straining of the hull of the ship in a seaway."

JORDAN DEVELOPMENT — "According to consular reports, it is the intention of the Turkish authorities, at Jerusalem, to establish a steamship line on the Dead Sea. The existence of asphalt in that region has been ascertained, and it is supposed that petroleum will be found also. A rational development of the Jordan Valley from Lake Tiberias down, and especially the opening up of the rich mineral resources of the Dead Sea basin, is considered a very profitable undertaking."

CABLE STEAMER — "One of the great companies, the Commercial Cable Company, owns and operates three complete submarine lines between Europe and the United States. To keep these cables in order this enterprising company has a fine steamer, the Mackay-Bennett. She is 260 feet long, 40 feet beam, and 22 feet deep, and propelled by twin screws driven by independent compound engines. The Mackay-Bennett is provided with three cable-holding tanks with a total capacity of 385 nautical miles. . . The steamer is fitted up with all the modern machinery for grappling, picking up and paying out cable. . . On the deck are placed two powerful engines for heaving in and paying out the cable."



GAS VS STEAM — "The gas motor occupies less space than the steam engine with its boiler and chimney, and it has the advantage as regards attendance, for one man can look after several gas engines, while a steam engine plant of any importance requires an engineman and stoker, and often an additional hand to keep up the coal supply. Another advantage of the gas motor is the fact that it can at any time be put to work immediately."

HEELS — "One of the latest features of wood pulp industry is the manufacture of shoe heels from that material, white pine and other kinds being used for the purpose."

WOODWORKING — "No branch of mechanics has received greater development in the United States than that which relates to woodworking. America has been pre-eminently a wood-producing country, and has brought shaping, planing and sawing machinery into the greatest perfection."

SULPHUR — "The Standard Oil Company has finally solved the great problem, on which hundreds of thousands of dollars have been spent in vain, of getting at the immense mass of sulphur which lies some hundreds of feet below the surface in Calcasieu Parish, Louisiana. . . Superheated water is forced through ten inch pipe on the sulphur, melting it, and the liquid sulphur water is then pumped up. A little exposure to the air, so as to evaporate the water, leaves almost pure sulphur. The experiment has been a success beyond expectations."

CALCIUM CARBIDE — "The production on the large scale of calcium carbide to be used for the manufacture of acetylene gas is now being carried out at the works of the Wilson Aluminum Company. By heating in an electric furnace a mixture of lime and carbon a combination of the two substances ensues, and a stone like material, the calcium carbide, is produced. When water comes in contact with it, part of the hydrogen of the water combines with the carbon, forming acetylene; the rest of the hydrogen, with the oxygen of the water, combines with the calcium, forming calcium hydrate."



Target practice with Relays and Keys

(Left to right) The operator punches the problem data on tape, which is fed into the computer. The solution emerges in the teletype receiver. Relays which figure out the problem look like your dial telephone system.

In designing the gun-control systems which shot down enemy planes, Army ballistic experts were faced by long hours of mathematical calculations.

So Bell Laboratories developed an electrical relay computer. It solved complicated problems more accurately and swiftly than 40 calculators working in shifts around the clock.

Resembling your dial telephone system, which seeks out and calls a telephone number, this brain-like machine selects and energizes electric circuits to correspond with the numbers fed in. Then it juggles the circuits through scores of combinations corresponding to the successive stages of long calculations. It will even solve triangles and consult mathematical tables. The operator hands it a series of problems with the tips of her fingers — next morning the correct answers are neatly typed. Ballistic experts used this calculator to compute the performance of experimental gun directors and thus to evaluate new designs.

In battle action, Electrical Gun Directors are, of course, instantaneous. Such a director helped to make the port of Antwerp available to our advancing troops by directing the guns which shot down more than 90% of the thousands of buzz bombs.

Every day, your Bell System telephone calls are speeded by calculators which use electric currents to do sums. Even now, lessons learned from the relay computer are being applied to the extension of dialing over toll lines.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE



As Reflected In Dichroic Coating Of Optics By Swain Nelson

When the new techniques of coating are correctly executed, precision optics cease merely to be highly polished pieces of glass, but take on new properties and offer possibilities once undreamed of.

The high type of artistry and technical perfection put into the Dichroic coating of lenses by Swain Nelson experts offers amazing selectivity as to light reflections and color transmission. Close to 100% efficiency is the standard result you may expect from Swain Nelson Dichroic coating.

Throughout the war period and since, Swain Nelson techniques in coatings of all types—including low reflecting coatings, and aluminizing, on a production basis, have attracted inquiries and business from some of America's largest manufacturers.

SWAIN NELSON COMPANY

2320 GLENVIEW ROAD GLENVIEW, ILL.

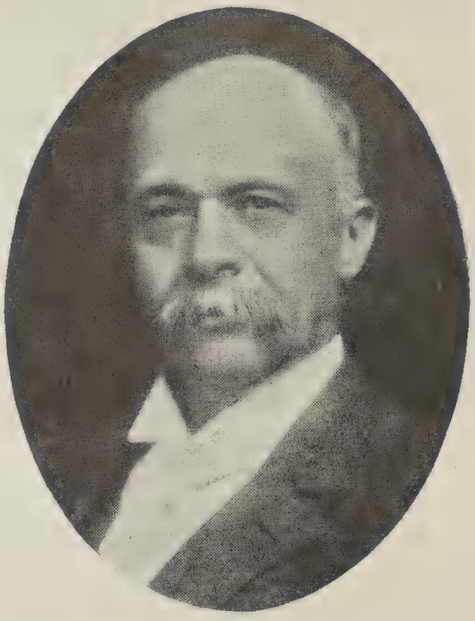
Creators and Manufacturers of

OPTICAL, ELECTRONIC AND RELATED PRODUCTS

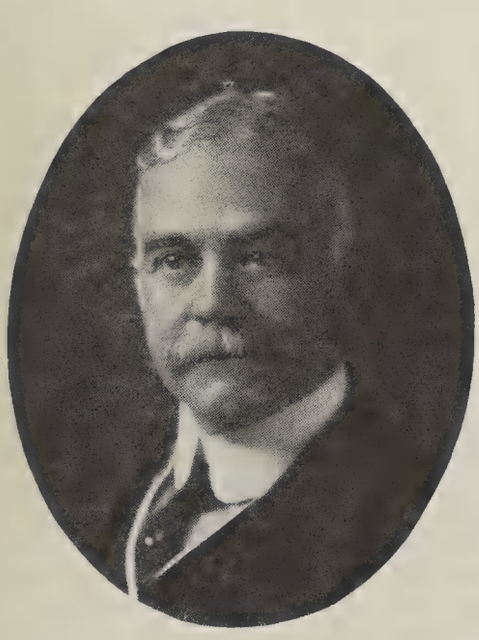
Scientific American
DECEMBER · 1945







Upper left: ORSON D. MUNN, co-owner of Scientific American from 1846 on with ALFRED E. BEACH, (above). Upper right: FREDERICK C. BEACH, who was secretary of Munn & Co., for many years following the death of his father Alfred. Left: CHARLES A. MUNN, who acquired the Scientific American business from his father Orson and from the Beaches. Right: Present editor and publisher, ORSON D. MUNN, nephew of Charles and grandson of Orson





A Century of Scientific American

By ALBERT G. INGALLS

Founded as a Serious Newspaper for All Americans Whose Interests Were Scientific, Mechanical, and Inventive, Scientific American Grew Up with America's Great Age of Invention and Took Prominent Part in that Age. Its Main Aim Has Always Been to Report Technological Progress, Especially as it May Affect Industry

BEFORE the writer lies prized, century-old Volume 1 of Scientific American, dated 1845, its pages only slightly browned with age, otherwise in a perfect state of preservation. Physically it is almost as large as a modern newspaper, its pages measuring 15 by 20 inches. Its publishers in 1845 thought of it as a newspaper and called it such—not a magazine. Scientific American a century ago was a new species of periodical, a specialized newspaper for those Americans whose interests were scientific. It aimed "to furnish the intelligent and liberal workingmen, and those who deligh



A view of the interior of the Scientific American offices of the period of 1859 to 1882. Reproduced from an issue dedicated to the 50th Anniversary of the founding of the publication

in the development of those beauties of Nature, which consist in the laws of Mechanics, Chemistry, and other branches of Natural Philosophy, with a paper that will instruct while it diverts or amuses them, and will retain its excellence and value, when political and ordinary newspapers are thrown aside and forgotten."

To find enough material of a scientific nature, in the limited circumstances of the American community of 1845, to fill a newspaper with things scientific must have taxed the resourcefulness of Rufus Porter, the publisher, during the opening year of the periodical. Yet within only a very few years Scientific American (published from 1846 on by Munn & Co.) became so widely known that matter of that kind gravitated toward it from all over the nation and world.

At first, however, everything scientific, near-scientific, and only slightly scientific had to be grist to Rufus Porter's mill, and his struggles to keep the new venture alive and make it grow show plainly through the picturesque pages of 1845. "If our paper appears dull this week," he confides to his subscribers in the number for January 22, 1846, "our readers must attribute the fault in part to the dullness of our exchanges, for we can assure them that we have selected the brightest ideas from nearly 200 newspapers, besides adding the best of our own." "The best of our own" consisted of original feature articles and, in each number, "two to five original engravings, many of them elegant, and illustrative of New Inventions, Scientific Principles, and Curious Works." In addition there were "general notices of the progress of Mechanical and other *Scientific Improvements;* American and Foreign Improvements and Inventions; Catalogues of American Patents; Scientific Essays, illustrative of the sciences of Mechanics, Chemistry and Architecture; useful information and instruction in various Arts and Trades; Curious Philosophical Experiments; Miscellaneous Intelligence, Music and Poetry." For some years each early number of Scientific American contained a column of poetry—at least it was verse—and not a few homilies on temperance. Except for these components the aim of Scientific American today centers around the same scope—things of a practical and industrial kind.

The subscription price to Scientific American was two dollars a year and the paper was published weekly. The publisher announced each week that "any person procuring two or more subscribers will be entitled to a commission of 25 cents each. Postmasters who will send us four subscribers shall be entitled to one copy gratis." Subscriptions were payable in advance and "persons desiring to subscribe, have only to enclose the amount in a letter."

Bound volumes of Scientific American occupy in its present publication offices 19½ feet length of shelf-room, or 33½ feet if the Scientific American Supplements are included. Often have the editors of the present, and no doubt all those of the past, looked at this long vista and resolved someday to read all of those fascinating back numbers. Futile hope! Merely to turn the pages and examine the illustrations would require more time than a modern editor can find. But no normal human being could even turn over those same pages without an urge to stop and read. The editor who each month selects the items for "50 Years Ago in Scientific American," complains that he suffers perennially from "repressed complexes" because the pace of modern work does not permit him to read every word of the fascinating volume he surveys.

ELEGANT STREET CAR — The very first number of Scientific American affords as succulent browsing, as far as sheer reader interest is concerned, as any in the earlier years. The "superbly long, elegant car," states the caption beneath the opening illustration (see front cover), "runs with a steadiness hardly equalled by a steamboat in still water, while flying at the rate of 30 to 40 miles per hour. Let any person contrast with it the awkward and uncouth cars of '35." Perhaps as we read this we smile, yet if we of today smile at the best that 1845 could offer, we shall in turn deserve to be smiled at by someone writing the story of Scientific American's first *two* centuries in 2045.

Page 2 of Scientific American's first issue tells its readers that "Morse's Telegraph, this wonder of the age, which has for several months past been in operation between Washington and Baltimore, appears likely to come into general use through the length and breadth of our land. Arrangements are already made for extending the lines to Philadelphia, New York, Albany, Buffalo, Springfield, Boston, and various other cities and sections. It is contemplated by the merchants of our Western states, to communicate their orders for goods, &c, by means of the telegraph, instead of abiding the slow and tedious process of rail-road cars."

HEADLINES OF 1845 — The same maiden number of Scientific American announced that the Frenchman, Martiner, has invented a panoramic daguerreotype camera with a curved metallic plate.

The skeleton of a carnivorous mastodon 23 feet in length is being exhibited in New York. (In 1845 there was nobody of scientific knowledge to which publisher Porter could turn to check an impossible claim for a "carnivorous" mastodon.)

Pittsburgh is building 26 iron furnaces of 100 tons daily total capacity.

There is much talk of introducing electro-magnetic light as a substitute for oil or gas. Just exactly what this prophetic terminology connoted, publisher Porter does not state in the ancient files of Scientific American nor in any private record preserved today. (Readers in 1945 sometimes ask for "further data from your records" on things published in Scientific American as long ago as half a century, but even editors grow old and die, and so do records.)

On the third page of his first number the publisher editorialized scornfully concerning Signor Muzio Muzzi's travelling balloon. "We doubt," he asserted, "whether any event has transpired within the present century, which has served to develop the ignorance and gullibility of the citizens of New York to so great an extent. We have been distressed with mingled sensations of regret and vexation to witness the applause of several of the most popular city papers, and men of reputed scientific attainments, appended to a certificate of commendation of a contrivance, the futility of which is so palpable at first sight, that a schoolboy of nine years would be censurable for dullness if he could not readily detect it."

The futile contrivance consisted of a spherical balloon to be steered by a rudder. Suspended beneath the balloon was to be a sloping or diagonal plane. When the balloon ascended, the sloping plane would drive it ahead. When it had risen to its summit its gas was to be valved off and the plane was to be reversed, so that the descending balloon would proceed an equal distance farther; or, in all, two miles! "Such, gentle reader," ridiculed the infant ancestor of the magazine you are reading, "is the invention which has been lauded by our first men and biggest editors."

AIR-MINDED — Not, however, that Scientific American wasn't air-minded even in 1845, for it offered, three weeks later, on its own account, "an aerial apparatus, on perfectly rational and established principles, that will navigate the atmosphere at a speed of 100 miles per hour, with safety, and perfectly at command; being in the form of an elliptic spindle, with a buoyancy of several tons, and driven forward by the power of steam, applied to revolving spiral fan-wheels."

The original woodcut of this proposed pre-Zeppelin dirigible deserves detailed and serious examination. The 350-foot balloon was to be hydrogen-filled. It was to be stiffened by 16 lengthwise rods—would weigh 7000 pounds and, with a 12,000-pound lift, would carry a net useful load of 5000 pounds. A two-horsepower engine which, the publisher stated, "we have already constructed and put into operation, if built on a scale of ten horse-powers, or if necessary, 30, will drive two spiral fan-wheels 16 feet in diameter and give a speed of 100 miles an hour."

The rudder was to consist of "two broad fans, intersecting each other at right angles in the centre and controlled by four lines, by means of which the direction of the balloon is completely governed, both horizontally and vertically."

"This balloon being once inflated, is intended to be kept constantly afloat, being moored at about 100 feet distance from the earth. With regard to the safety of this mode of travelling, we think there will be less danger in travelling over land in aerial vessels, than there now ordinarily exists in travelling by either sailing vessels or steamboats. The balloon will be furnished with an improved parachute for each passenger."

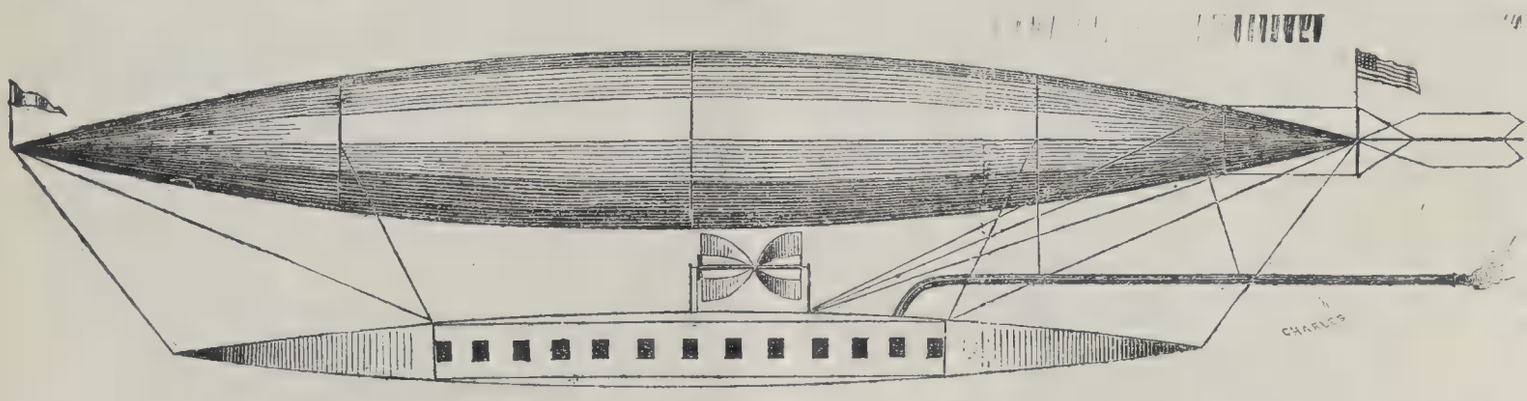
Not so accurately prophetic was a note in June, 1846: "A project is in motion for extending a submarine [telegraph] line between England and France; but it is known to many in this country that the plan is utterly impracticable."

UNINHIBITED — In Volume 1, No. 5, the outspoken, uninhibited publisher Porter hotly resented a slur. "It is reported," he wrote, "that our paper is generally well received, and that the only objection is that 'it is too small for the price.' We can assure the stupid, senseless boobies who make this assertion, that we could afford the paper at one-half its present price, if we were to fill two pages with advertisements. We should be glad," he continued, "to instill a little common sense into the heads of such people, but as that cannot be done, we must be content to furnish our paper to those who have more consideration than to suppose that the value of a paper is in proportion to its dimensions."

After eight weekly numbers of Scientific American had appeared the periodical's publication offices in Spruce Street, downtown, then mid-town, Manhattan, were completely burned with a loss of $700, and there was no insurance. The account in Scientific American a month later when publication was resumed tells us that the flames were at the door, and that Rufus Porter siezed his most valued possession, the subscription list, and rushed through these flames to gain the street. A young man who was present in the offices had asked for a pail of water and then impulsively followed the publisher to the street "without attempting an application of it." Thus from the flames were rescued two things, the infant Scientific American's precious subscription list and a bucket of water.

In June 1846 Rufus Porter, so Scientific American's columns state, made a business trip to Washington, D. C., and conveniently skipped a number, apologizing in the next number. This precedent will be an attractive one to all editors of the present day!

ENTER MUNN AND BEACH —When Scientific American was almost a year old, publisher Porter sold his interest to two young men, Orson Desaix Munn, grandfather of the present editor and publisher of the same name, and his school-mate chum, Alfred Ely Beach. The sale price was $800, roughly equivalent to $1500 today,



Reproduction of "The Travelling Balloon," from the September 18, 1845 issue of Scientific American. Said the editor: "The practicability of travelling rapidly and safely through the air, has been already established, so far as theory can establish a point without actual experiment; and the principles . . . have been already thus established."

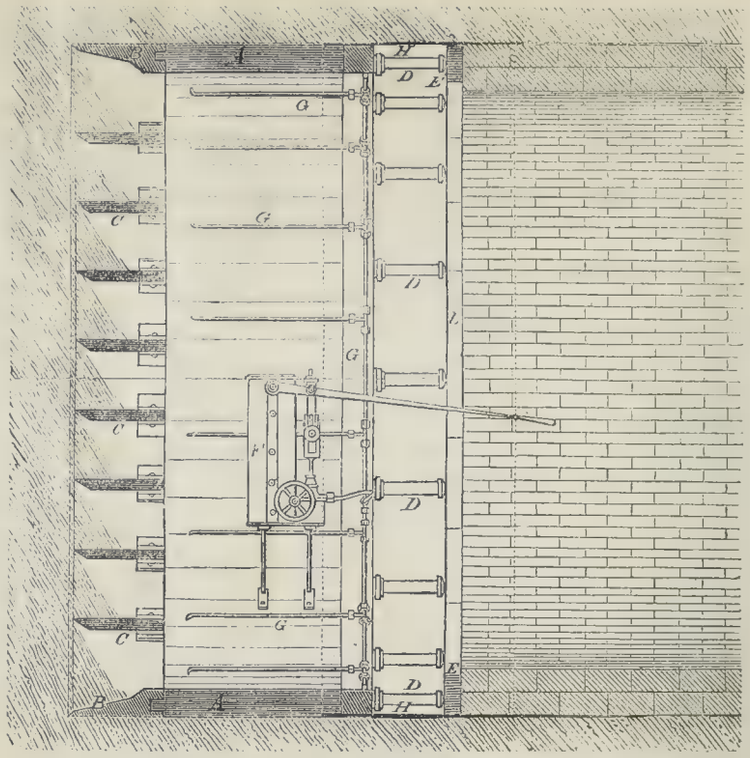
and each man put up half of this amount. Munn was then twenty-two and had recently come to New York City from Monson, Massachusetts, where his father had a general store. Educated at Monson Academy, at 19 he had become a clerk in a bookstore in Springfield, Massachusetts. This experience eventually proved to be the turning point in his career, for he then became conscious of the future possibilities in the publishing field. He later became a clerk in his father's store and post office in the village of Monson and, being gifted with a keen business sense, he built up a reserve of capital which was later to start him in business in New York.

Mr. Munn lived to the age of 82, dying in 1907, and devoted much of his time during the intervening 60 years to Scientific American as Editor. His active span therefore covered fully 60 percent of the whole life span of Scientific American even today.

Alfred Ely Beach was only 20 years of age when Munn and Beach bought Scientific American, but he had spent some years in the office of the New York Sun, then owned by his father. This experience was of great value in building up the small and still struggling little journal which they had purchased. And because Beach was a minor, his friend, Orson Munn, held his half interest in trust until he became of age, at which time a partnership was formed known as Munn & Co. This name appeared on the mast head of Scientific American from then on.

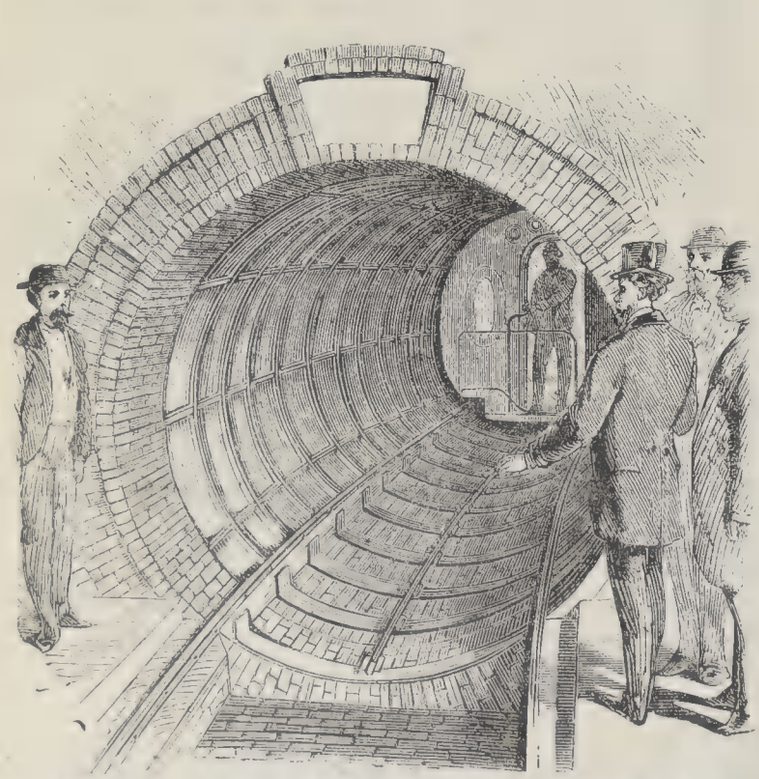
Mr. Beach, a man of versatile mechanical bent and great perspicacity, was intimately associated with the preparation and prosecution of patent applications which were later undertaken by the original partnership and gave personal supervision to practically all the patent work done by the staff of Munn & Co. Beach, in fact, was a mechanical genius and an inventor of note, among his inventions being one of the first successful typewriters and the tunneling shield which made possible the construction of his experimental subway under Broadway, the forerunner of New York's present vast subway system.

Under the management of Munn and Beach, the periodical lost in quaintness, picturesqueness, and excentricity but gained in authority and standing. No further editorial referring to "stupid, senseless boobies" and the like are to be found in the files, indicating, no doubt, that Rufus Porter, while remaining for a time as Editor, was under constraint of greater decorousness and dignity imposed by the new owners. After another year he dropped out of the picture entirely, and thereafter Scientific American was urbane and—from the point of view of an antiquarian searching a century later for entertaining evidences of rugged individuality—considerably less provocative of chuckles.



A cross-section of the tunneling machine or shield, invented by Alfred E. Beach, of Scientific American, and which not only made possible the construction of the first subway but served to establish the principles upon which tunnels are still constructed. The cutting edge of the shield is at B and the hydraulic jacks at D

INVENTION AND INDUSTRY — The page size was reduced to 11 by 15 inches and the number of pages was increased from the previous four to eight. Paper and printing were improved, more illustrations were pre-





The doors of the Beach Pneumatic Transit Company were opened to the public on February 26, 1870. At left is a view of the tunnel and at right a section of one of the cars that were driven by air from "a gigantic blowing engine"

sented, and from this time on emphasis was placed by publishers Munn and Beach on the interests of the American inventor and American industry.

A resident correspondent was placed at Washington, "in a measure connected with the Patent Office," so that "our subscribers will receive the first notices of any NEW INVENTIONS. The latest foreign inventions will also be published." This was the beginning of the Patent Department of Scientific American and for 50 years the two went hand in hand—the periodical proper, largely devoted to mechanical progress and its Patent Department for encouraging and assisting inventors.

Steadily the new journal, unique in kind, grew in size and circulation. In 1849 the circulation was 12,000, in 1852, 16,000. Little attention was paid to advertising. In fact, advertisers were made to jump through the hoop as soon as circumstances permitted. The advertising section each week, beginning in 1853, carried a rate card. An advertisement of four lines cost for each insertion 75 cents; 16 lines, $3.00. Accompanying this is a statement which may give modern advertisers cause to grin or faint: "Advertisements exceeding 16 lines," it stated flat-footedly, "cannot be admitted; neither can engravings be inserted in the advertising columns at any price." With such a frank, forthright statement there could be no possible argument.

NEEDED BY MANUFACTURERS — An editorial in the same number called attention to the new typography and paper, and the fact that the weekly paper had been increased to 16 pages. "All the patent claims, as issued by the Patent Office, will be published every week," the publisher stated. "On this account no man interested in patents should be without the 'Scientific American,' and if he is wise for himself he will not. There is not a manufacturer in our land but should be a subscriber, because he does not know but some invention may come up any week to revolutionize his whole business. It affords us no small degree of pleasure to know that many of our countrymen have been greatly benefitted in circumstances because they have been readers of the 'Scientific American.'"

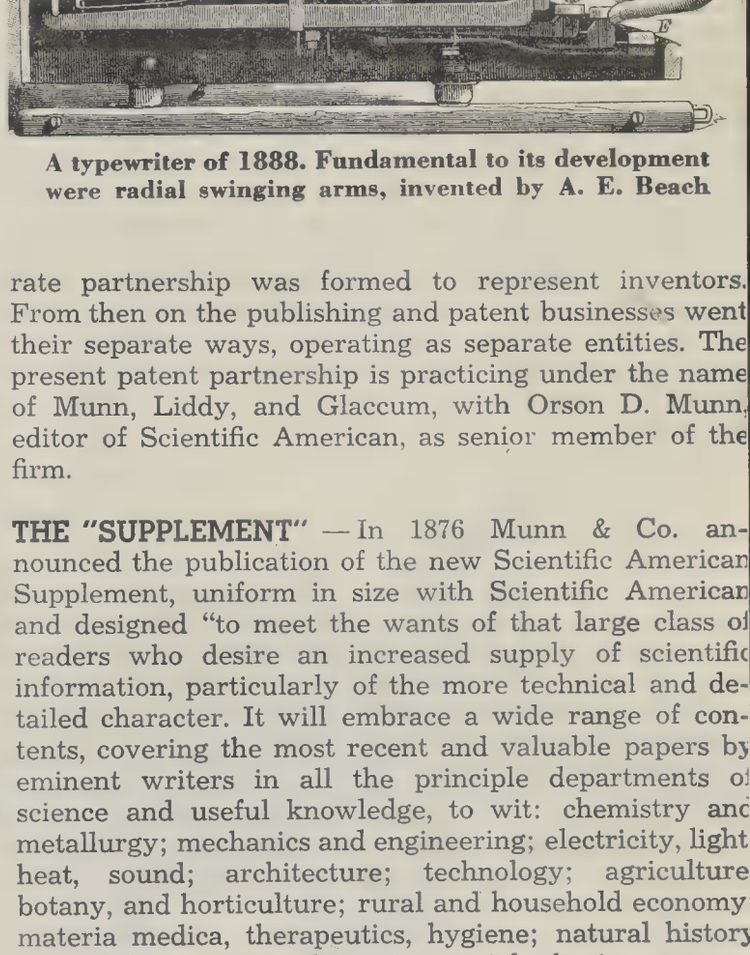
Thus this periodical has had a large share in the industrial growth of the nation. It arrived on the national scene at a period in our history when invention was on the upsurge, yet when a virtual vacuum existed in regard to media of publication through which mechanics—today we would refer to them as mechanical engineers and machine designers—could meet, as it were, in the printed page. It became the focus of their common interests and thoughts and, since the enterprise was conducted in an intelligent manner, it thrived lustily. "There are at least 6,000,000 of our population interested in inventions, science, chemistry, and the arts," continued the editorial of 1853. The great wave of invention which was to place this land in the industrial lead was advancing and Orson D. Munn and his partner Alfred E. Beach, the country youths, were on the spot at the correct time waiting for it.

A century ago patent attorneys were practically unknown. Isolated inventors scarcely knew how to proceed to obtain patents and market their inventions. Scientific American, with a corps of experts on patents, became the genial sun that thawed out this frozen situation. A former commissioner of patents, Judge Charles Mason, was retained to head the periodical's patent department and a branch office, an essential link, was opened at Washington. The business grew rapidly. At the time of Munn's death 60 years after he and Alfred Beach purchased Scientific American for $800, more than 100,000 patents had been secured for clients.

Naturally, Scientific American's offices soon became a resort of inventors in the flesh, and to them came men now famous in the history of invention to consult with the editors—Capt. Ericsson, Commodore Stevens, Capt. Eads, Samuel Morse, Elias Howe, Dr. Gatling, Peter Cooper Hewitt, Thomas Edison, and others of fame. In 1877 Edison dropped in one day with a package under his arm, which he silently proceeded to open and whose content announced itself, when he turned a crank, by speaking the words: "Good morning. How do you do? How do you like the talking box?"

The editors of Scientific American were among the first to see the Edison incandescent lamp, the Edison dynamo, and the Edison moving picture machine, the "kinetoscope," and it is not Edison's fault that we do not today go to the "kinetos" instead of the movies.

For half a century the Patent Department of Scientific American flourished and Munn & Co. served the dual purpose of publishing an industrial journal and advancing the interests of inventors. Then, in the early 1890's, a law was passed prohibiting corporations from practicing before the Patent Office. At that time a sepa-



A typewriter of 1888. Fundamental to its development were radial swinging arms, invented by A. E. Beach

rate partnership was formed to represent inventors. From then on the publishing and patent businesses went their separate ways, operating as separate entities. The present patent partnership is practicing under the name of Munn, Liddy, and Glaccum, with Orson D. Munn, editor of Scientific American, as senior member of the firm.

THE "SUPPLEMENT" — In 1876 Munn & Co. announced the publication of the new Scientific American Supplement, uniform in size with Scientific American and designed "to meet the wants of that large class of readers who desire an increased supply of scientific information, particularly of the more technical and detailed character. It will embrace a wide range of contents, covering the most recent and valuable papers by eminent writers in all the principle departments of science and useful knowledge, to wit: chemistry and metallurgy; mechanics and engineering; electricity, light heat, sound; architecture; technology; agriculture botany, and horticulture; rural and household economy materia medica, therapeutics, hygiene; natural history and zoology; meteorology, terrestrial physics, geography; geology and mineralogy; astronomy." The Supplement was a separate and independent publication.

No longer by then was a "scientific newspaper" unique. Other more technical scientific journals were being published and from these journals Scientific American Supplement reprinted the best selections

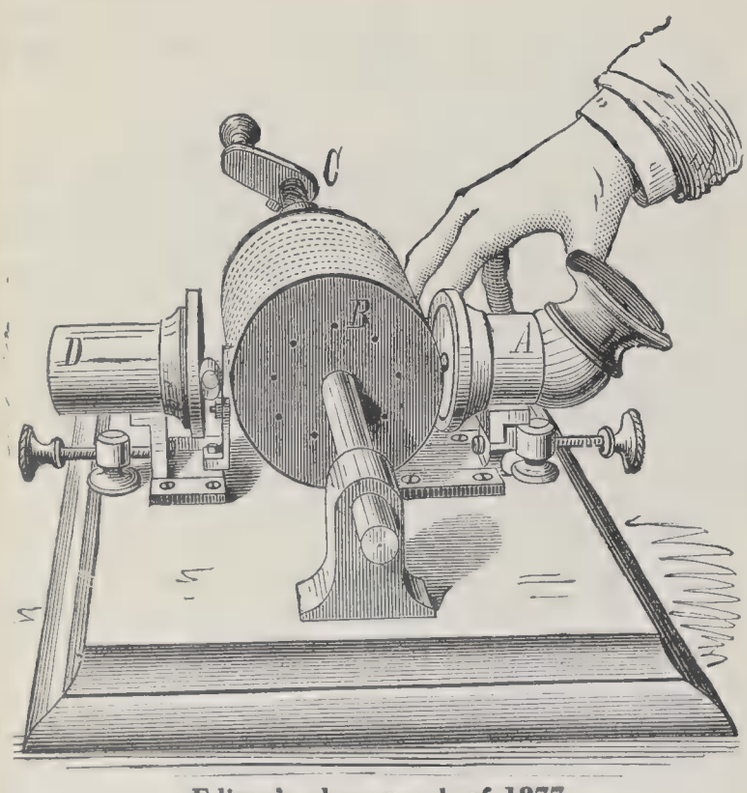
with credit to the sources. Thus, by subscribing to the Supplement the reader could, in a sense, subscribe to a hundred other periodicals. The Supplement was published until 1921 when it, the child, was swallowed by its parent publication which at the same time became a monthly. Explaining this major change of policy the editor candidly stated:

"The position which the scientific weekly held 75 years ago, when Scientific American was founded, is no longer a sound one. In 1845 the daily press gave the scantest space to scientific matters. There was a real demand for a periodical devoted to the world's advance, which should not necessarily give such complete or such technical statements as the quarterlies and the annuals of the physicist, the chemist, the electrician and the engineer, but which should enable the intelligent reader to get a sufficient idea of what has been done, and to get this without waiting for the appearance of quarterly or annual.

"Today," it continued, "this is no longer the case. The daily papers give excellent summaries of every scientific advance, of every invention of importance. As regards the mere function of a scientific newspaper, it is obvious that the weekly can compete with the daily no more than the quarterly could compete with the weekly."

In short, times had changed and the serious newspaper for scientific Americans of 1845 no longer enjoyed near uniqueness. A formidable book of 814 large pages, entitled "A World List of Scientific Periodicals," published in 1934 (Oxford University Press) and available for inspection in most large libraries, contains the names of over 36,000 (thirty-six *thousand*) such journals.

TODAY — Scientific American has traced the trends of the times for 100 years, often presenting its reports in advance of the obvious trends. And its development into the industrial publication of today is just as logical as was its change from a weekly to a monthly in 1921. Before Scientific American was started in 1845, there was no "newspaper" that served the mechanically inclined; in 1943 (when the last major change was made in the editorial policy of Scientific American) there was no general magazine that reported technological progress for industry as a whole. It was simply a case of expanding industrial coverage, with a background of almost a century of experience in industrial reporting. Into that niche, which sorely needed filling, stepped Scientific American with its September 1943 issue. Today, with a group of contributing editors who are individual specialists in their own industrial fields, its pages not only report technological progress but interpret and prophesy as well.



Edison's phonograph of 1877

Thus Scientific American is the dean—the senior—of American periodicals of popularized science. Even among professional scientific journals only two in this nation, *The American Journal of Science,* largely devoted to paleontology, and *The Journal of the Franklin Institute,* are older. A century of Scientific American's history is essentially a century of American advance in scientific and industrial progress and invention.

OTHER ACTIVITIES — It is only natural that a successful magazine publishing concern should at times turn its attention to book publishing. But realizing that its first interests should concern the magazine, Munn & Co., Inc., has entered the book field only in a specialized way. For over 40 years "The Scientific American Cyclopedia of Formulas" has been the standard of its kind and has run through many editions and hundreds of thousands of copies. "The Finger Print Instructor" is another volume that has made an enviable name for itself. It is the "Bible" of police departments throughout the country and is widely used by the F.B.I., in private detective work, and in industrial plant personnel operations.

In the middle 1920's the writer of this article published a series of articles in Scientific American on the subject of amateur telescope making. As a result, further information was requested by readers in such great numbers that a small book entitled "Amateur Telescope Making" was published. Its reception was warm indeed, and now, in its fourth edition, it is a full-grown volume of some 500 pages. The appeal of telescope making as a hobby requiring more than usual application and diligence was so great that the elementary book was followed by a companion volume named "Amateur Telescope Making—Advanced." Altogether, these two books have been sold in numbers approximating 40,000, with an estimated readership of several times that number.

At the height of enthusiasm for amateur photography in the decade prior to World War II, Scientific American published a book for those camera users who wanted fundamental instruction in how to get the best results from their cameras. This volume, "So You Want to Take Better Pictures," is now out of print.

In addition to its specialized activities in the book publishing business, Scientific American conducts a book department for the benefit of its readers. In connection with this service, its pages each month carry a number of reviews of the latest books of other publishers. These books are made available through the department, whose slogan is: "We can supply any book in print."

PRESENT EDITOR — Since 1923, Orson Desaix Munn, grandson of the Orson Desaix Munn, the enterprising clerk in a Massachusetts village general store who almost a century ago purchased a half interest in a struggling new venture and built an institution that is closely linked with the history of American invention, is the publisher and editor of Scientific American. First associated with the publication in 1906, he succeeded to the editorship upon the death of his uncle, Charles A. Munn, to whom the publication was bequeathed by its builder. Mr. Munn is a Princeton graduate Litt.B., and holds the degrees of LL.B. from New York Law School and Sc.D. from Oglethorpe University.



On July 4, 1855 R. T. Crane poured the first metal in this little foundry in Chicago.



90 YEARS

of Service to Industry

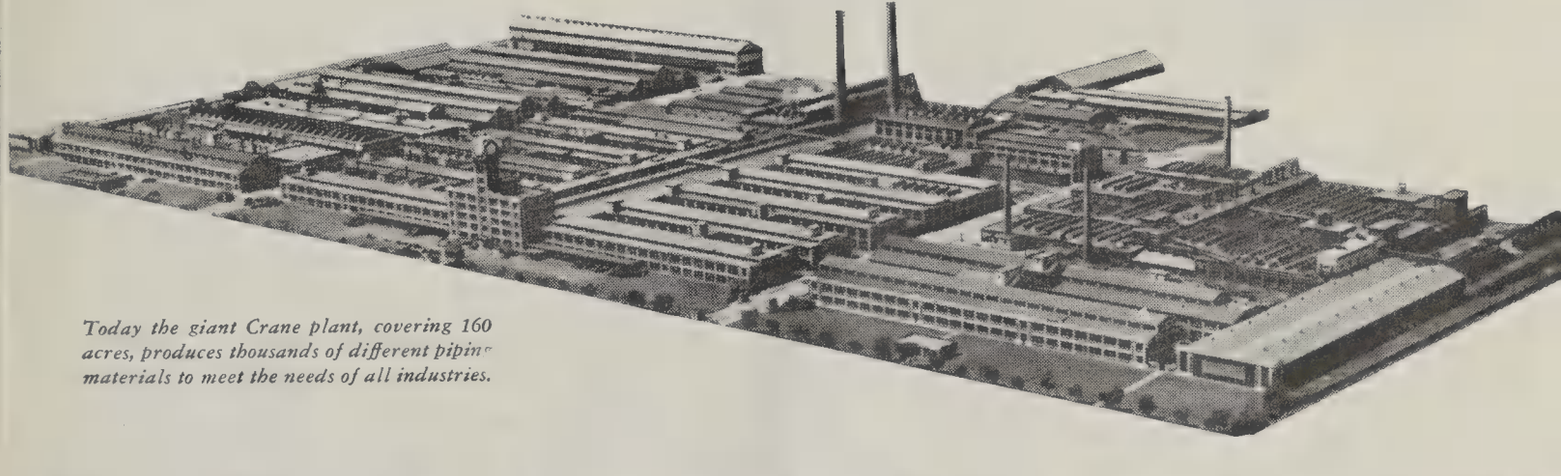
When R. T. Crane poured a ladle of molten metal into a flask 90 years ago, a new industry was born.

The growth of Crane Co. from 1855 to 1945 is symbolic of the growth of America's dominance in production, for Crane Co.'s business is supplying the valves, fittings and pipe so essential to all industry.

It is difficult to conceive of any production that does not depend to a greater or lesser extent on piping. For wherever steam, air, water, oil or any other liquids flow, it takes valves, fittings and pipe to control them.

Today Crane Co. is the world's largest producer of flow control equipment and the Crane line includes: "everything for every piping system." Users of piping are familiar with Crane's nation-wide distribution that serves every section of the country through Crane Branches and Wholesalers.

Crane Co., 836 S. Michigan Ave., Chicago 5, Ill.



Today the giant Crane plant, covering 160 acres, produces thousands of different piping materials to meet the needs of all industries.

CRANE

90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE

PLUMBING • HEATING • PUMPS

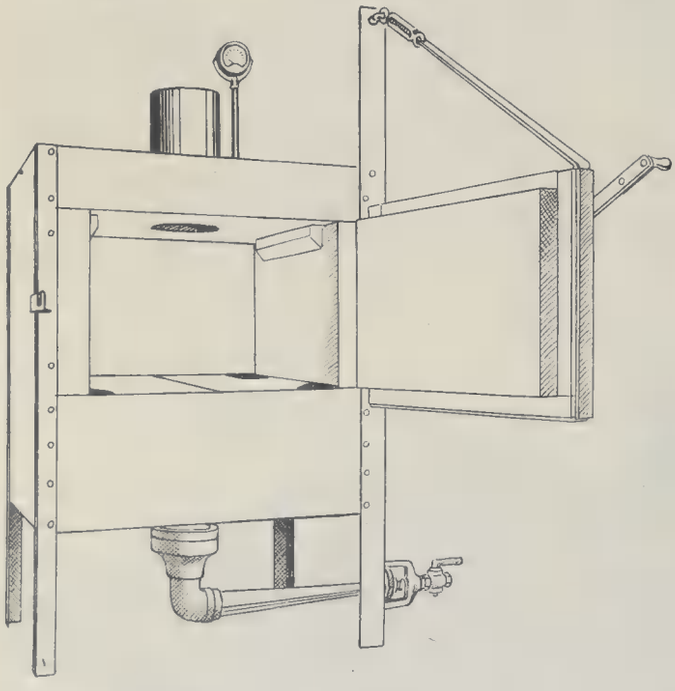
BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS

Lost Wax At Work

Precision Castings Can be Produced Commercially by the Lost-Wax Process, but Not by "Off-in-the-Corner" Methods. Materials, Processing, and Equipment Must be Fitted to the Job in Hand; then Lost Wax Can Show Outstanding Advantages in Accuracy and Scrap Reduction

A PRECISION cam which is the nerve center of a business machine needed 59 machining operations to complete it. Many of its dimensions had to be held to plus or minus .001 inch on irregular contours; its cam-curve outside diameter was held to plus or minus .0025 inch.

Naturally, the precision machining spoilage was high. Allowing an average of less than 1 percent spoilage on each operation, the manufacturer would have to start with 150 blanks to obtain 100 finished cams. The overall costs added up to more than $7 a cam.



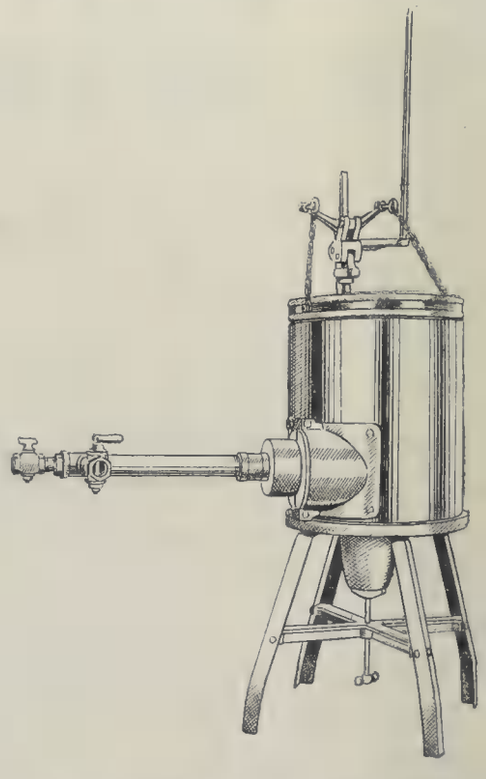
Right: Gas fired melting furnace for metals

Left: Gas fired furnace for eliminating wax

Lost-wax* precision-investment casting allowed this cam to be made for $1.25, a saving which when multiplied by the usual factors applying to manufacturing mark ups would provide $15 a machine for reducing the retail price, or for sales and advertising costs, or for cash reserves and profits. But before such a result could be had the company management's attitude toward lost-wax casting had to change.

This company, like so many others, had regarded lost-wax casting as an "off-in-the-corner" process which almost anybody could operate. After all, the process is simple. A full sized model of the part to be produced is made of metal, wood, or any other hard material, a mold with suitable parting faces and sprue passages is made around that model, wax is poured into the mold to form a wax replica of the model with its sprue, several wax replicas are ganged by connecting their sprues, an investment is poured around the gang, the investment is hardened or "set," the wax is evacuated by putting the investment into a furnace and "losing" the wax up the chimney as gases, and molten metal is poured into the investment where the wax used to be. Cut or dissolve the investment away from the cooled metal, cut away the sprues, and there are the finished parts with accuracies as close as .001 inch.

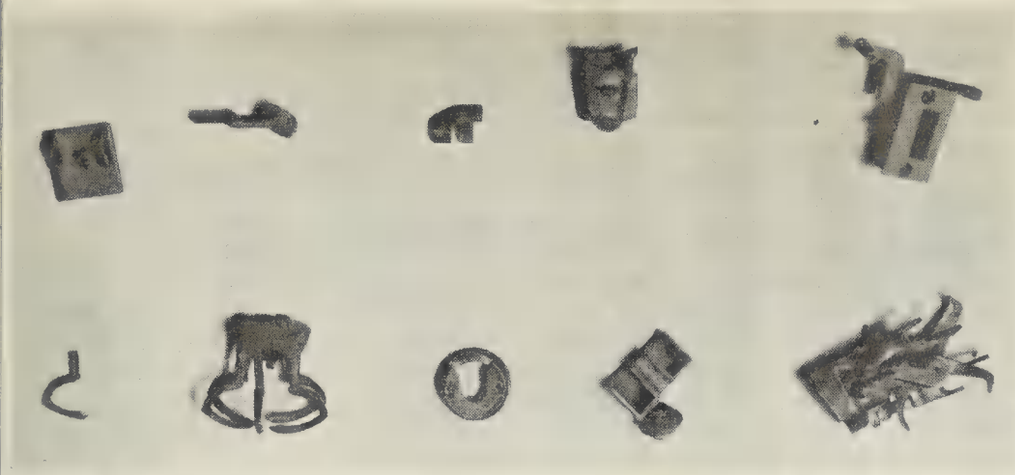
The trouble is, molten metal will shrink, swell, warp, turn porous, become harder in some areas than in others, and play other tricks as it cools. The company tried the simplest form of lost-wax precision casting and found the part coming neither to true dimensions nor to acceptable metallurgical quality.



DOWN TO CASES—Then a consultant, Baker Castings, was called in and real work began. First of all, the model had to be changed. This company had believed the all too common statement that a finished piece of correct dimensions is all that is needed for a model, and had proceeded accordingly in its original experiments. And, of course, where the finished dimensions do not need to be too close, as in ornamental parts making, the original piece does make a good model. But if cast metal is going to shrink or warp as it cools then the dimensions of the model must be changed to compensate for all that.

The final model was by no means

*For further details on the lost-wax casting process itself, see page 259, December 1943 issue of Scientific American. — Editor.



Courtesy Ecco High Frequency Company

Small parts like these, made from brass, gold, platinum, high carbon, and stainless steel are quickly and accurately produced by the lost wax method

an oversized version of the original piece. Lost-wax casting has methods which can improve products as well as its own processes, and some of these were used.

A pin, for example, ground to .0001-inch accuracy, was used in the molding of the wax replica. Withdrawn from the wax, this would leave a hole which would be within the tolerances usually achieved by grinding-in the finished piece. The hole would be only three sixteenths of an inch in diameter and eccentric to the axis of the piece; a size and position in which internal grinding would have been so difficult to perform that the company had abandoned the idea of obtaining the desired accuracy.

Soft rubber plugs attached to parts of the mold could be pulled straight out from the wax replica, causing them to stretch thin and come out without distorting the wax. One of these was used to form an oil hole which followed a curved path from the side of the piece to an oil chamber at the axis of the piece. Another formed the oil chamber itself, with the chamber recessed in the middle of the piece and the sides coming down to the diameter needed for the bearing bushing. Without this lubricating arrangement a costly drilled shaft would have had to be used to get oil to the bearing.

Arrangements like these brought the company's product designer into the picture. Lost-wax casting was ceasing to be considered an odd process for the production of one part of the machine, and was working its way into the family of processes which make up the production line.

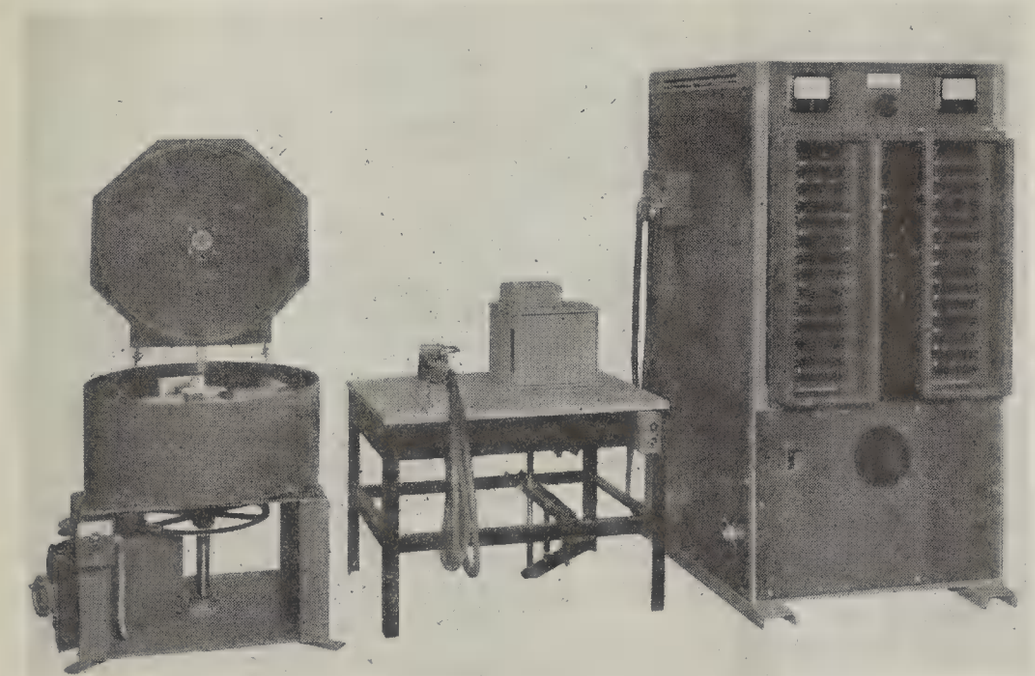
NEW MATERIALS—With the new process a stainless steel could be used for the part. In fact, lost-wax precision casting works better on alloy steels than on plain carbon ones. This brought the metallurgist into the picture.

Finally came the question of the cost of lost-wax casting. It was found that, although this process can hold very fine tolerances on nearly any dimensions, the cost can be less if some tolerances are allowed to go to plus or minus .005-inch. Furthermore, although lost wax does produce smooth surfaces and true ones, it does not yield the brightness and smoothness of ground ones.

The decision was made to cast some dimensions slightly oversize and grind to size. And thus lost-wax precision casting worked itself fully into the production scheme as a production line process which feeds other processes. Part of this decision involved selecting the control surfaces by which the parts were to be chucked for grinding. These had to be made of ample widths for the collets to grasp, and of high concentric as well as parallel and dimensional accuracy. Further modification of the part was involved, with consequent remaking of the model.

Installation of a lost-wax precision castings department was considered. But the company found that the lost-wax process shares one condition with forgings, screw machine products, stampings, die castings, plastics, powder metallurgy, and



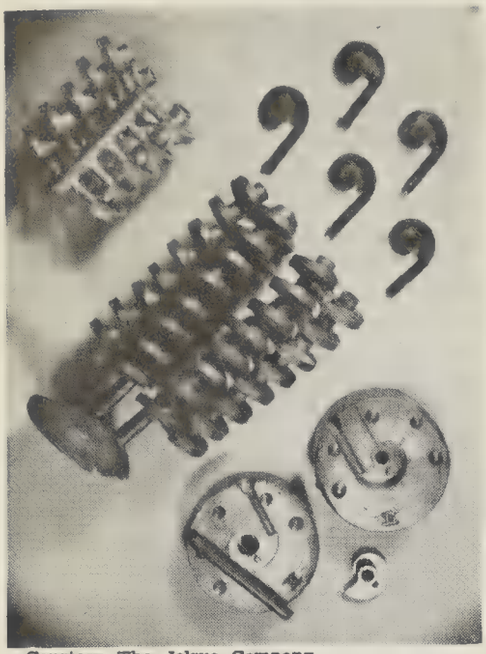


Courtesy Ecco High Frequency Company

Above: Electric equipment for lost wax casting—casting machine, furnace, high-frequency converter. Above, at the right: Unit for making four castings at once

other resources available to machinery makers. There are wide varieties of equipment available, and each variety has special but limited abilities. Contractors which devote themselves mostly or wholly to this process either have widely varied and highly adaptable equipment to take on almost any job, or else have highly specialized production lines to do extra good work at low prices on narrow ranges of products.

Equipment for lost-wax casting has been developed very rapidly. Old-line makers such as the Jelrus Company, Ecco High Frequency,



Courtesy The Jelrus Company
A typical set-up showing the mold, investment, and the molded product

Detroit Dental Casting, Kerr Dental Manufacturing Company—to mention a few—and specialized supply houses like Alexander Saunders and Company, are bringing out new and improved equipment and supplies at a rapid pace. Companies like General Electric have some new products and ideas too. Furnace makers such as Baker are well up in the equipment parade.

The fact is, lost-wax precision casting equipment and supplies form a tempting target for every phase of industry.

BETTER WAXES—The waxes—primary key to the whole process—must be capable of assuming high dimensional accuracies when forced under pressure into molds, of flowing into all sorts of recesses, of assuming true shapes when molded to such contours as threads and sharp re-entrant angles, and of holding their accuracies and contours while handled by human hands or by machines at room temperatures. Many improvements in the qualities and abilities of waxes have been made, others are on their way. Waxes which, for example, will have higher structural stabilities in thin walled sections, soon will be obtainable. Some of the "waxes" are plastics which contain little or no wax. Complete evacuation ability is needed too.

Investment materials, the secondary key to the process, are another chemist's opportunity in this business. The investment must be capable of penetrating to the tiniest openings in the contours of the cast wax, and of holding true contours while being set, while the wax is being gasified and evacuated, and while heavy and somewhat abrasive molten metal is being forced into them under the pressure of centrifugal casting. The higher the structural strength of the investment the more complex, heavy, and large can be the castings—structural strength of the investment also affects the final accuracy of the part. Most of the present investments are ceramics. But graphite-bearing materials and others familiar to metal melters are in use. And in the test-tube stages are investments which under the heat of the molten metal will release nitrogen or other oxidation inhibiting materials, or will provide other special surface conditions on the finished parts.

Molds for casting the waxes are receiving a great deal of study. They can be made of plastic rubber which later is vulcanized—this is the simplest process. Some of the bismuth alloys are especially adapted to the making of these molds. Molds can be made of hydrolized wood (Masonite die stock) or of plastics. They can be sunk by die makers. In short, molds for wax are a brand new invitation to imaginative tool and die makers.

The metallurgical end of the production line offers chances for metals makers and users to remove some of their limitations. The fact that the process works at its best on some of the metals which are too high in melting points for die casting, too tough for machining, and too hard or brittle for extruding, already is putting plenty of lost-wax casting equipment to work. The advantage that this process wastes only the very least of the raw material to machining chips and to scrap of any kind, is one of the main reasons why it appealed to jewelers and other users of precious metals before it did to industry as a whole. Lost wax will solve many a problem where scrap losses are headaches. In many a shop it will be practical to transfer chips, rod ends, and other scrap to the lost-wax line and convert them into useful products with raw materials costs calculated at only scrap values.

EQUIPMENT—Any kind of metals-heating equipment from oil and gas furnaces to dielectric and induction heaters can find employment here. Some of the most modern equipment uses electrical means to melt the metal right in the casting machine. It is practical to run such equipment—and other casting equipment—in controlled atmosphere chambers and thus get rid of oxidation and other problems.

Supersonics methods can improve both the applying of the investment and the casting of the metal. Electronic equipment, pyrometers, and other control instruments find plenty of use.

With all of this available the company decided to use the services of a contractor until it got its lost-wax precision-casting experience ripened a bit, after which it could install its own equipment. But many another company has gone through this stage and has its own lost-wax production line going at full speed.

Lost wax may yet solve such problems as the commercial molding of such exceedingly hard materials as boron carbide (Norton's "Norbide"). But aside from these experimental opportunities, the process has a firm grip on production lines; it has come of age.

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SENSITIVE CONTROLS

Use Principle of Changing Electrical Resistance

USE HAS long been made of the fact that a wire of a given alloy changes its electrical resistance with changes in diameter. One very old use, for example, is to find the diameter of an extremely fine piece of wire of a known alloy by measuring its resistance and from this computing its diameter.

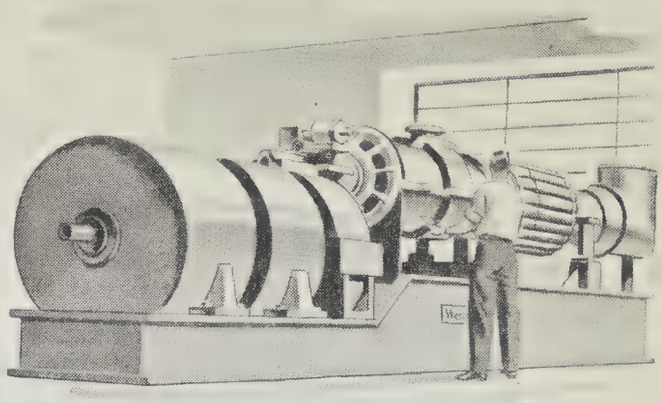
With the diameter and alloy already known, use has been made of this same principle by measuring the amount which the wire stretches under extremely minute movements of devices which are attached to its ends. When the wire stretches, its diameter is reduced and its electrical resistance goes up. Movements of as little as one millionth of an inch of the devices fastened to the wire ends can thus be accurately measured.

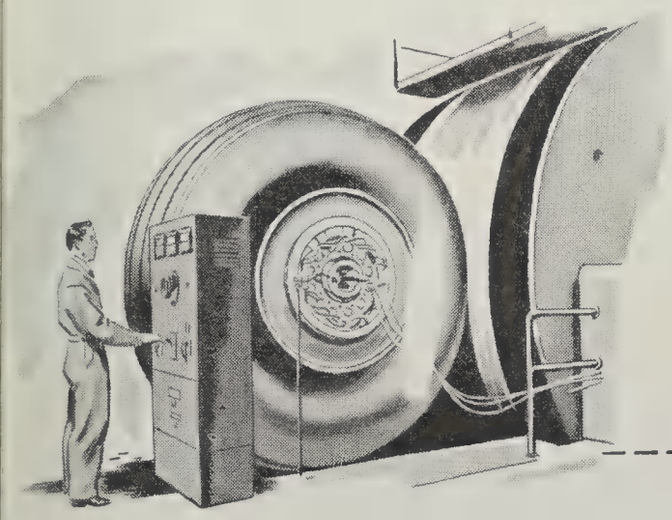
Instruments which measure tiny movements in this way are known as strain gages. They measure the bendings or twistings of machine parts such as gears and shafts under load, and thus permit the accurate analysis of the loads which these parts are carrying.

Latest reported use of the principle is to measure the pressures of gases or liquids. The pressure is imposed on a member to which one end of the fine wire is attached; this member moves accordingly, and the amount of its movement and therefore of the pressure upon it is found by the changing electrical resistance of the wire. By electronic means this resistance change is amplified and caused to register on instruments, to make records, or to operate pressure regulating automatic controls.

In a laboratory a SCIENTIST experiments with a new gas turbine . . . using heat-resisting alloy blades that are far stronger, at 1100°F., than *ordinary* steel at room temperature.

. . the name on the GAS TURBINE is Westinghouse.





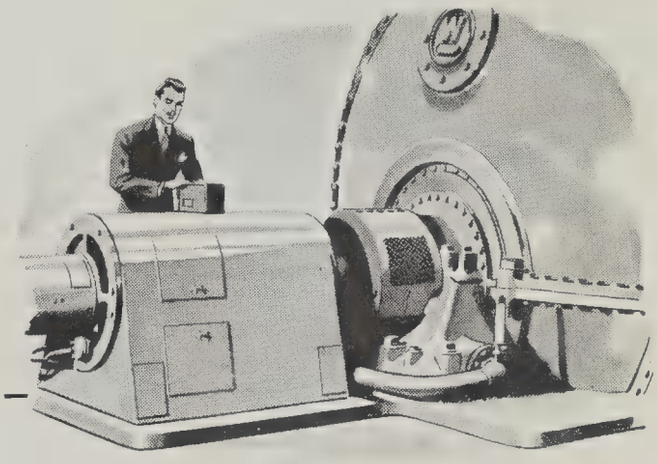
On a special machine a TESTER employs a Rototrol* for smoothly accelerating a large flywheel, used in determining the wear-resisting qualities of tires and brakes—for huge air transports of the future.

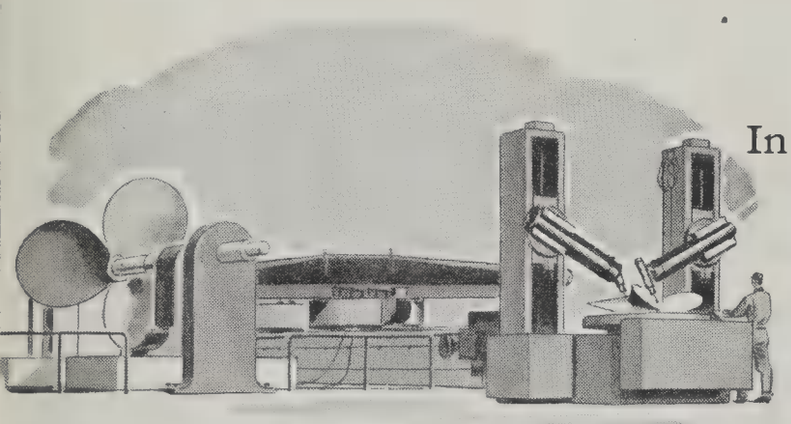
. . the name on the ROTOTROL is Westinghouse.

*Registered Trademark

In a power plant an ENGINEER uses a Vibrograph to "take the pulse" of a turbo-generator . . . recording the smallest vibrations as a trace on a film.

. . . the name on the VIBROGRAPH is Westinghouse.





In a manufacturing plant an OPERATOR uses an electronic control to regulate the movement of milling cutters—for accurately machining irregular contours on giant ship propellers.

. . . the name on the ELECTRONIC CONTROL is Westinghouse.

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PLANTS IN 25 CITIES OFFICES EVERYWHERE

NOW THAT Westinghouse technical skill and "know-how" have turned from war to peace, expect great things . . . from Westinghouse research, engineering, and precision manufacture.

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Your Home In Plastics

Combining Utility With Beauty, Plastics Provide the Modern Small Home With Transparent and Radiant Walls, Giving the Illusion of Greater Size to Small Rooms. Plastics are Used for Curtain Rods, Colorful Door Knobs, Drawers, Trays, Tables, Chairs, and Bath Fixtures

MATERIALS of all types have come in for their share of over-publicity in the last few years, and plastics are no exception. To counteract this condition and to help crystallize the thoughts of architects, homebuilders, and buyers alike, Rohm and Haas Company has designed and constructed a full-size, compact bedroom, dressing room, and bath assembly wherein plastics are used only where good engineering and good design dictate. This exhibit was constructed with one idea in mind—to show how plastics in home furnishings and fittings can be at once functional and attractive. Plexiglas is the only plastics used throughout this mock-up except for the bedroom curtains, spread, and pillow covers which are of Koroseal, and the Tego-bonded plywood closet doors and dresser fronts.

Most home-owners have frequently longed for an air conditioning unit, particularly for the bedroom. Yet too many have refrained from positive action in the belief that such equipment would be overly costly, both to install and maintain, An unusual solution to the problem is this exhibition bedroom which is held to a size that permits the efficient operation of a small air-conditioning unit at a cost approximating that of a home refrigerator.

LIMITLESS ROOM—To offset the closed-in feeling that might come with solid walls enclosing such a small space and to give the impression of almost limitless room, curved transparent sheets of acrylic are used as the front and half of the side partition. This space-giving wall sweeps around to the doorway, also of acrylic sheet, which opens without noise or effort by sliding back into the other wall.

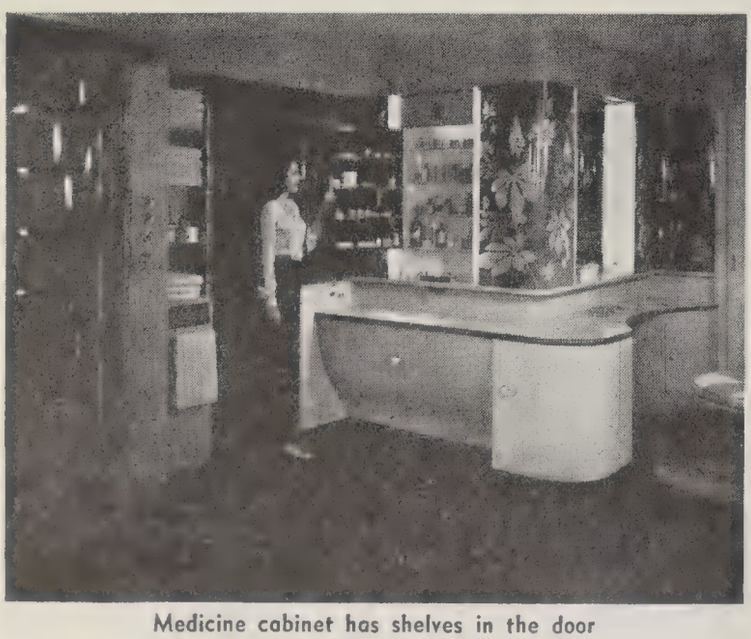
An equally unusual feature of this sleeping room is the mural that arches over the head of the bed. In the exhibition room the scene is one of lighted skyscrapers reaching up into the darkened night, but the design could as easily have depicted a green forest, a surrealist's nightmare, or a child's dream

The three-dimensional effect and the startling lighting achieved in this mural are produced by engraving or painting individual elements of a design on separate pieces of acrylic, each the size of the finished mural. The top layer was painted with buildings for the foreground, the next sheet with those a bit further away, while the last or bottom piece was entirely covered with a solid background of color. Small air spaces separate the various layers.

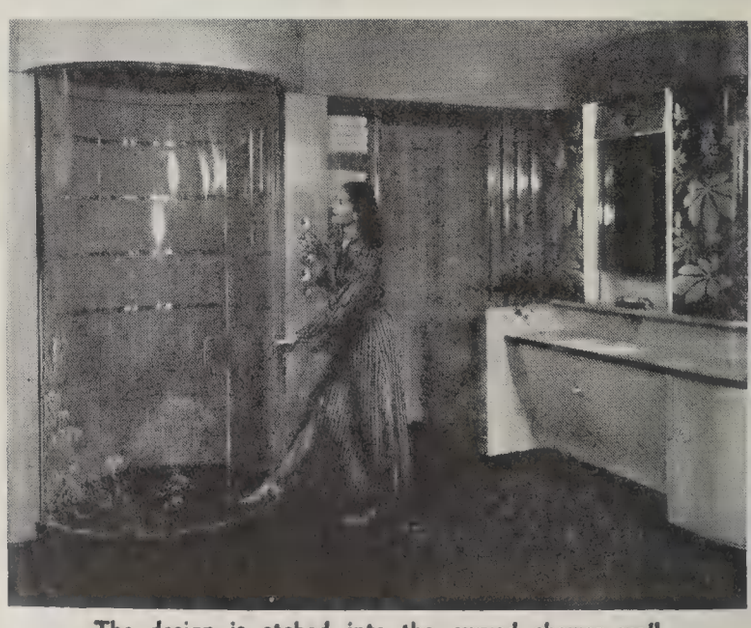
Before insertion into position in the wall, the mural is provided with edge-lighting from a concealed light source. This light causes the etched or painted portions of the acrylic sheets to glow and sparkle, producing a mural that is truly "painted in light."

Small by comparison with the mural but equally well designed for the role it must play is the clear flat strip of acrylic which acts as a curtain rod for the multi-striped polyvinyl chloride curtains in the bedroom. More important than the ease of installation is that these pieces can be wiped clean with a damp cloth. And, unlike the usual metal rod, this flat strip of transparent plastics sheet blends into the walls and drapes, and does not need to be painted.

The knob of the bedroom door is a good example of the ingenious manner in which color is combined with transparent acrylic materials. To get a colorful, workable unit,



Medicine cabinet has shelves in the door



The design is etched into the curved shower wall

a hole was bored in a clear acrylic knob, then color poured into the space in the center. Another piece of this same plastics, pierced by a bolt, was next cemented to the knob, acting as a means to attach the knob to the door.

SPACE-SAVING—As in the entire assembly, not an inch of space is wasted in the attractive dressing room. Even a projecting corner just outside the bedroom door has been put to use as a hat and shoe closet. Double doors swing wide to reveal



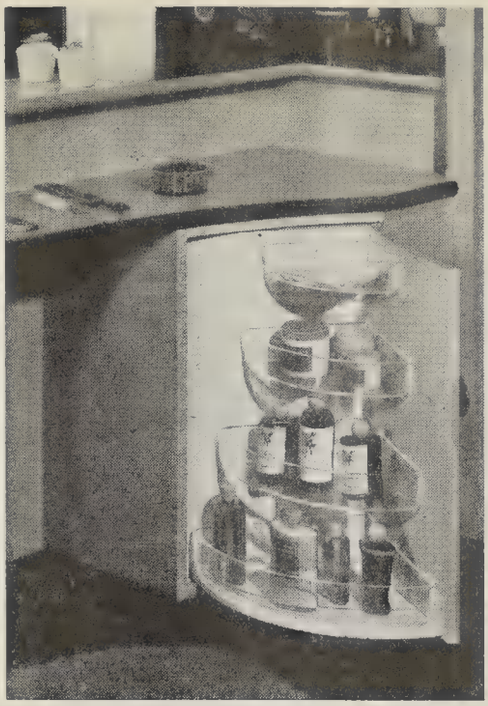
Air conditioned spaciousness in the bedroom is achieved by use of transparent walls and edge-lighted mural

a hat rack at the top and three tiers of transparent acrylic shoe shelves at the bottom. About 15 small hats can be accommodated on the revolving rack, which is formed entirely of acrylic bars.

Near the dressing table is a double closet which provides space for full-length evening gowns, street-length dresses and suits, and men's coats, trousers, and so on. Drawers, built in above the clothes rack and on the floor, add considerably to the storage space in this unit assembly.

Acrylic handles on the drawers in this closet serve a second purpose —that of label holders. Slips of paper printed with the contents of particular drawers can be slipped under the transparent handles which are in the form of a scroll. The acrylic acts as a magnifying glass so that the labels can easily be read from a considerable distance—or by a somewhat nearsighted person.

RADIANT WALLS—Both the decoration and the illumination of the dressing room come from its walls. To accomplish this double purpose, they are covered with a sheet of Plexiglas which has been engraved and painted with a design—in the case of this exhibition room, a color-



Curved plastics trays—easy to clean

ful and bold chestnut leaf pattern. Hidden fluorescent lamps edge-light the wall, causing it to glow radiantly wherever the paint or engraving has interrupted the smooth polish of the normal acrylic surface. The theory behind this effect is like that of the bedroom mural, only in this instance one sheet of acrylic is used instead of several. This wall follows the curves of both the dressing room and bath, and provides general illumination for both rooms.

This somewhat new concept in room lighting is comparable to the "warm wall" idea of room heating—the light spreading out evenly from the entire wall instead of intensely from a fixture. In both the radiant wall and the mural painted in light, a different design is seen by reflected light than is evident when the acrylic sheets are edge lighted.

Special provision has been made for bottles, jars, small articles of clothing, and the odds and ends which usually hide themselves away as soon as they are needed. Within easy reach is the perfume niche whose circular shelves will hold a myriad of bottles. Illumination is provided by the radiant wall which also forms the background of this tier of shelves.

One side of the dressing table swings open to reveal a set of removable transparent acrylic trays for cosmetics, hose, and other small articles. These trays are formed with deep sides and rounded corners which combine to make them easy to clean.

On the other side are three deep drawers which are designed to hold lingerie or other articles of apparel. These drawers are equipped with blown acrylic liners which can be quickly and easily removed for cleaning. After these liners were formed, they were sprayed on the back with a pale pink paint to make them opaque.

The huge dressing-table chair is a transparent drum formed from sheets of acrylic resin, topped with a tufted cushion covered with polyvinyl chloride fabric. With room enough for two, it does away with odd chairs that are always getting in the way in most bedrooms and dressing rooms. It also adds a strange lightness and sparkle which complements the airiness of the rest of the compact three-room unit.

What might otherwise be waste



Dressing-table chair is a plastics drum; perfume niche in right background has circular plastics shelves

space in the bath is again put to good use; a protruding corner is turned into a drying rack. Three bent acrylic rods are affixed to the door of this cabinet which is designed to be heated with a special unit so that drying time can be cut to a minimum.

Just beyond the drier is the oversize wash basin where baby can be given a bath or where small articles of clothing can be washed with ease. Like the drawer liners, this basin was deep drawn from clear acrylic sheet, then sprayed on the back with white paint.

The faucet handles are fabricated from heavy pieces of this same transparent plastic to a shape which is easy and comfortable to grip. They are cut in such a way that the clear plastics catches and reflects the light almost like a gem.

There is double space in the medicine cabinet because acrylic shelves are attached to the back of the mir-

rored door, supplementing those usually found in such cabinets. To prevent bottles from falling into the basin whenever the door is opened, each of these four shelves has an inch-high lip at the front.

POISON—The fear of mistakenly seizing a bottle of poison instead of some innocent medication seems to be universal. Recognizing this fact, the designers of this three-room suite have set aside one entire shelf in the medicine cabinet for poisons. To make doubly sure that no mistake can be made, this shelf is covered with a downward swinging sheet of red acrylic resin upon which the word "POISON" is painted in white letters.

And to top off the wash basin and medicine chest is the commuter's clock whose acrylic dial is lighted by fluorescent tubes set on either side of the mirror that covers the cabinet door. As with the fluorescent tubes around the dressing table mirror, these lamps also light the radiant walls.

The toilet, the smooth functional lines of which mean easy cleaning, is shielded from the remainder of the bath by a row of acrylic resin bars cut in the shape of prisms. Because of the reflections thrown from the surfaces of these bars, the acrylic appears to be opaque—providing complete privacy.

Just beyond, half-way between the wash basin and the shower stall, are towel shelves and racks, and a concealed hamper. Again, transparent acrylic resin sheets and bars are used to good account.

Immediately adjacent is the shower which is equipped with automatic temperature controls both outside and in. Anyone who has tried to regulate the flow of water in a shower without either freezing or scalding himself will appreciate the convenience of this dual system of water regulation.

The space-giving effect that can be achieved through the use of large sheets of acrylic resin is again put to test in the shower wall. One half of the wall of this shower consists of two pieces of curved Plexiglas, one of which slides back of the other to permit entrance to and exit from the stall. In this exhibition unit the transparent wall of this circular shower is etched with only the faintest design. However, should greater privacy be desired, the pattern could be so heavy as to make the sheets almost opaque. Just as with the rest of the illumination in this exhibit, the lighting for the shower comes from fluorescent tubes set into the wall on either side of the transparent enclosure.

A GOOD START—Many novel uses have been suggested for plastics in this life-sized bedroom, dressing room, and bath assembly—but as many more will probably occur to the reader. The way has been shown, however, in which beauty can be combined with practicality—with no sacrifice of either of these essential qualities.

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BOTTLE BREAKAGE

Higher in Glass Than in Plastics

SOME light is shed on the question of the comparative resistance of blown thermoplastics and glass bottles to shipping hazards by a series of tests recently carried out through the co-operation of a manufacturer of blown plastics bottles, two container manufacturers, and an independent testing laboratory.

A seven foot hexagonal drum, studded on the inside with various obstacles designed to subject the test packages to a great many different types of falls, was used for the test. For purposes of accurate comparison all bottles were of similar shape and size, or as nearly so as possible. Bottles made of three types of plastics formulation were tested: acetate; Butyrate; and polystyrene, as well as bottles made from flint glass. All the bottles were filled with a similar liquid and fitted with standard type closures. The cartons or boxes used to pack the bottles were of identical size and construction.

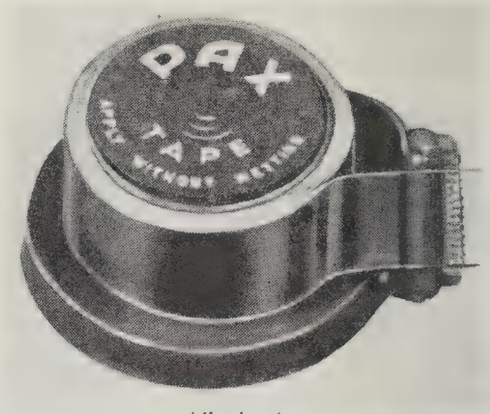
According to reports of the tests carried out, acetate bottles showed the greatest endurance, surviving five drum tests, each of which involved 150 falls of the drum, without visible damage. Butyrate bottles stood up almost as well as acetate, withstanding 150 falls in all but one of the tests. In the case of the polystyrene bottles, performance varied, breakage occurring after 36 to 104 falls of the drum. The glass containers performed according to long established standards—breakage occurring in each case after 46 to 69 falls.

SEALING UNIT

Has Plastics Housing and Uses Plastics Tape

A TRULY all-plastics application is a sealing unit put out by Cofax Corporation. Not only is the housing of the unit injection molded of Lumarith, but the tape is produced on a cellophane backing or Lumarith film.

The sealing tape holder is made up of two parts—a base and a snap-on cover. Both parts presented a number of molding problems to the Sterling Plastics Company. In the case of the base the difficulty was with the proper forming of the teeth which are used to cut the tape to the desired length. As for the cover, it was necessary that this piece snap in and out without too much pressure being exerted, yet hold firm when the sealer was used.



All plastics

The Pax dry seal tape is available in transparent form and in a range of colors.

UPHOLSTERY MATERIAL

Resists Constant Scuffing And is Easy to Clean

SINCE real leathers and fine woods are almost prohibitively expensive, manufacturers of dining-room equipment are always on the lookout for materials which will give the same effect of elegance yet will not require too large an initial investment. Furthermore, they are attracted by materials which will remain flexible, will not crack and spot, and will not lose color under constant exposure to light.

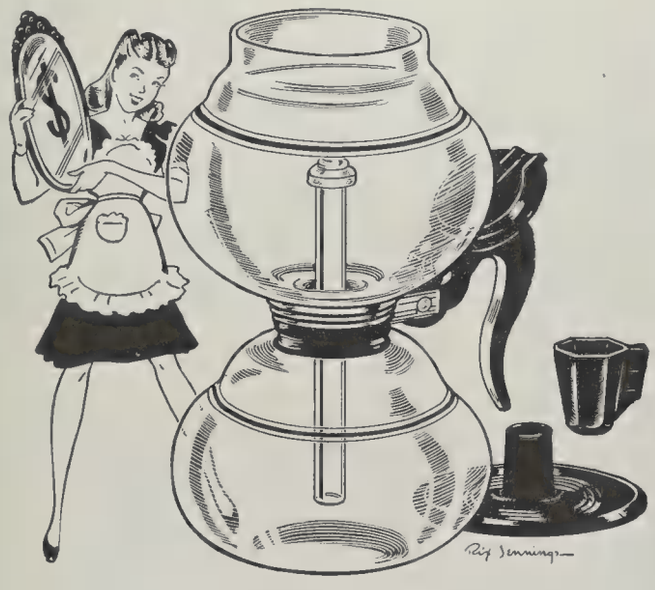
The Monsanto Chemical Company has come to the aid of these restaurant materials manufacturers with a vinyl butyral coated upholstery covering which is designed to meet all these adverse conditions. Used for the first time in the dining room of the Sheraton at Springfield, Massachusetts, the new covering has proved specially suitable as the outer lining of the pantry service door. Not only does it resist the constant scuffing it receives from the feet of waiters but it can be wiped clean with a damp cloth. And as a covering for the seats and benches that line the walls of this dining hall it has proved itself to be stain proof and remarkably resistant to sunlight.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

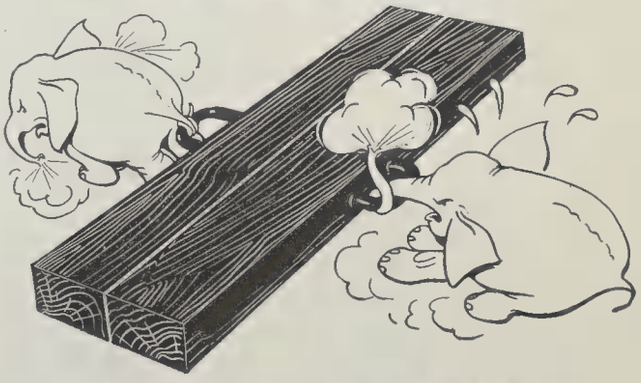
MOLDING COMPOUNDS



BREWING REAL PROFITS

Like most products which are being successfully merchandised in the highly competitive consumer markets of today, the Cory Coffee Brewer makes skillful use of plastics. The hinged decanter cover, safety upper glass stand, easy-grip handle, and measuring cup are all molded from a Durez phenolic compound. Such inherent characteristics as heat resistance, dielectric strength, brilliant finish, excellent moldability, highest dimensional stability at temperature extremes, and moisture resistance, make the more than 300 versatile Durez molding compounds of tremendous value to the imaginative design engineer... make them the natural starting point when you're looking for the plastic that fits your job.

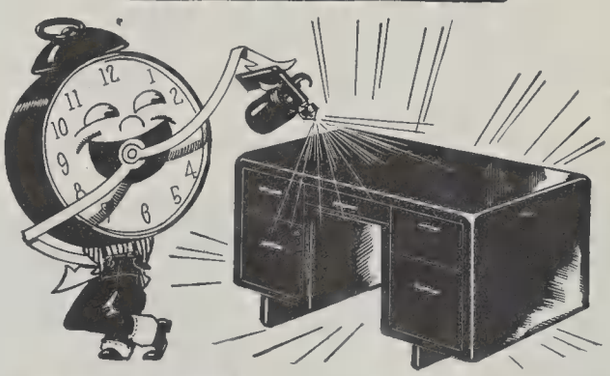
INDUSTRIAL RESINS



THEY SAID IT COULDN'T BE DONE ... AND IT COULDN'T!

Durez laboratory technicians said that the strength of a Durez 12688 bond was such that even elephants couldn't pull it apart...the wood would give way first. Subsequent tests (without the elephants) proved this to be absolutely true. In fact, a Durez 12688 bond is virtually indestructible. This remarkable room-temperature resin adhesive produces bonds which are just as durable and waterproof as those in hot-pressed plywood . . . opens up many new markets of which laminated lumber, keels, and prefabricated housing are but a few.

OIL SOLUBLE RESINS



HOW TO DO A DESK JOB . . . 24 TIMES FASTER!

Furniture which used to take three or four days for finishing can now be ready for packing and shipping in four hours if Durez 50824 Liquid Resin is incorporated in your paint manufacturer's formulation. This amazing new resin typifies the continuing leadership of Durez oil soluble resins in the protective coatings field.

The phenolics are the most versatile of all plastics and, therefore, are the most widely used throughout industry. As specialists in the production of phenolic plastics and resins for the past quarter century, Durez technicians have gained the vast experience so necessary for giving competent guidance to the newcomer. This rich background is further enhanced by the fact that these men have actively participated in the successful development of literally thousands of products. Their services are available at all times to you and your custom molder. A new booklet entitled "Plastics Primer" was recently completed by the Durez staff. Its purpose is to inform today's over burdened executive of the basic facts about phenolic plastics. You'll find it a brief, simple, crystal-clear digest filled with the kind of authoritative information you've been waiting for. Write for your free copy today. Absolutely no obligation, of course. Durez Plastics & Chemicals, Inc., 5212 Walck Road, North Tonawanda, N. Y. *Export Agents: Omni Products Corporation, 40 East 34th Street, New York 16, N. Y.*

PLASTICS THAT FIT THE JOB

Two-in-One Materials

Plating, Hot Dipping, Powder Metallurgy, Inserting, and Cladding, Offer Virtually New Materials With Desirable Properties for Many Specific Purposes. Plastics Plus Metals and a New Aluminum-Cast-to-Steel Process Open Many Fields of Application Hitherto Undeveloped

PROGRESS—technical and otherwise—often comes from unexpected directions. The war demanded many materials with special properties or combinations of characteristics not previously available, and the natural approach was to develop new alloys or improve the old to solve such problems. While several new materials were born out of this stimulus, the answer in many cases was found in composite materials—combinations of two different metals, for example, in which the best properties of each are utilized in a way not possible through alloying.

The composite materials have opened up a vast new field for materials engineers and metallurgists and, indeed, the technique has joined the more familiar alloying as a second method of achieving needed material characteristics for special applications. They are already being widely incorporated in the new peace-time products now being blueprinted or manufactured.

For such industrial products the two-in-one materials of greatest interest are metals plated or coated with other metals, duplex powder-metallurgy products, inserts of one material in another, composite metallic-nonmetallic materials, a wide range of clad-metal combinations, and bonded-assemblies of different metals, such as the Al-Fin cylinder barrels.

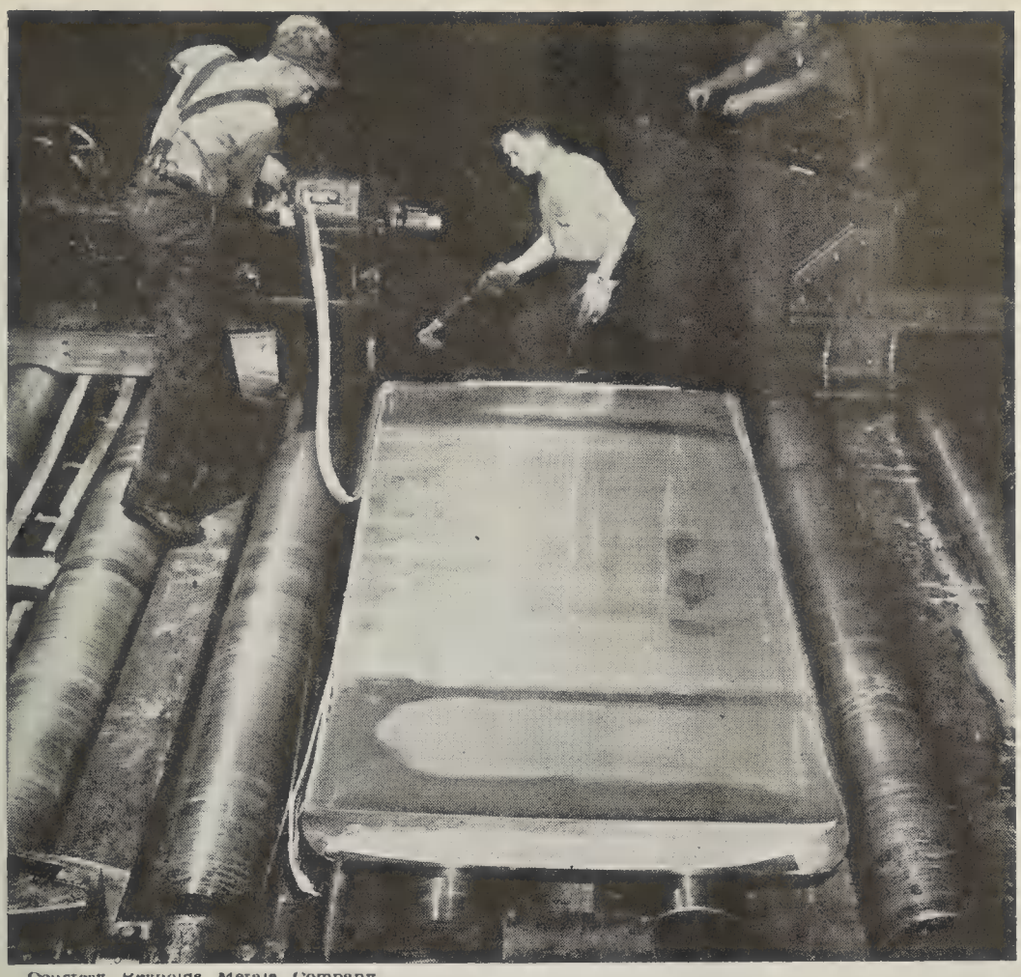
Although not popularly considered as composites, electro-plated or otherwise-coated metals are actually the oldest and most familiar of the duplex materials. A "tin" can, for example, is made of sheet steel coated with tin; the steel provides the mass-productibility, formability, and low cost required of can materials and the tin confers the necessary corrosion-resistance, non-contaminating quality, and solderability.

The double advantages of thin layers of one metal applied on another are widely appreciated, so that the application possibilities for some of the newer developments of this type are broad indeed. For example, the recently developed aluminum-coated steel sheet (produced by hot dipping) combines the corrosion- and heat-resistance, the reflectivity, and the appearance of aluminum with the cheapness and workability of steel, and may find uses in such diverse products as mufflers for internal combustion engines, oven and furnace linings, and firewalls in airplanes.

The reverse of this—the plating of other metals on aluminum—yields a product that features the light weight of aluminum with better surface wear or electrical-contact properties than those of the light metal. Thus gold and silver outer coatings are used where low contact resistance or high surface conductivity are required. Nickel and chromium may be employed to improve the wear resistance and tin or cadmium to facilitate soldering.



Composite aluminum and steel products made by the Al-Fin process



Courtesy Reynolds Metals Company

Hot rolling a slab of clad aluminum alloy material

Electronic equipment, electrical appliances, and aircraft instrument components are among the applications expected to develop for this type of plated metal.

Similarly the development of high-speed continuous zinc electroplating on steel promises a new, inexpensive duplex material for many purposes, such as automotive and radio-set stampings and general hardware—all of which will require the workability and built-in coating-adhesion of such pre-plated steel.

BUILT-IN DUPLICITY — Certain types of powder metallurgy parts are shining examples of built-in duplicity. Electrical contacts, in which copper and tungsten particles are unalloyed partners within the metal's structure, possess the conductivity of the copper and the hardness and arc-resistance of the tungsten.

The same principle applied to discrete aggregates of other dissimilar materials is being used to make bearings, friction plates, and armature brushes with one wear-resisting and one lubricating constituent; it will doubtless be expanded to give us light-weight aluminum aircraft bearings; thermal insulating refractory parts with the built-in extra strength of dispersed metal powders; and molded plastics products containing enough admixed metal powder to provide a metallic sheen or semi-luster for ornamental uses or to increase the strength of insulating parts for dielectric applications.

The possibility of using inserts of one material cast or molded into another has not received the attention it deserves. Steel pins in nonferrous castings and brass threaded studs in plastics moldings are familiar, but the opportunities for new combinations of built-in properties can go much farther than these.

For example, die castings in zinc, aluminum, and magnesium can be produced with cast-in or anchored steel springs, with brass bushings for bolts or bearing uses, with bronze strengtheners for extra-load-bearing, or with insulating plastics for localized insulation in an electrical part. Such applications, if more widely used, would bring the fast-production and close-tolerance advantages of die casting to industries like machinery building, automotive engine manufacturing, and railway equipment production whose highest mechanical strength requirements have often led them to avoid the use of die castings for structural parts.

The combinations of metals and nonmetallic materials that are now available provide one of the most fertile fields for modern designers, especially in architectural and building products, in furniture and consumer durable goods, in boats, and, of course, in aircraft. The automotive industry has long made successful use of plastics-metal composites, as in many modern dashboards.

Several engineers are sure that laminated products—a light nonmetallic material in thick section combined with a strong alloy in thin section—may provide the combination of light weight, strength, and general rigidity needed in many fields. An interesting recent development of this type is a combined wood-and-aluminum sheet which possesses strength, lightness, rigidity and eye-appeal as well as resistance to fire, termites, and seasonal temperature changes. These qualities will make the material especially attractive for post-war buildings, railway cars, buses, and private airplanes. [Other metal-nonmetallic composites have been described in recent articles on plastics in April, and on glass in September, Scientific American.]

METAL ON METAL—The clad metals represent today the largest two-in-one material tonnage produced and offer the greatest opportunity for exploitation by designers. The Alclad aluminum alloys and stainless-clad steels, for example, are already well-established products with great potentialities.

The pure-aluminum-clad alloys were developed to provide a sheet material for airplane construction that would have the strength of the underlying age-hardening aluminum alloy with the corrosion resistance of the pure aluminum surface. The recent improvements in both underlying strength and surface (fatigue) strength inherent in such new and stronger combinations as Alcoa's Alclad 75 S and Reynold's R 301 and R 303 have now broadened the market for the clad aluminum alloys to include all types of transportation equipment and home appliances as well.

Stainless-clad steel is today the fair-haired boy of the duplex materials field, with the possibility ahead that it may reach production tonnages near those of straight stainless a few years ago. The stainless clad steels are made by a variety of processes but in their final form they are all sheet or strip material consisting of a thin layer of stainless steel permanently bonded to a heavier base of ordinary steel.

This combination in effect offers the corrosion resistance of stainless steel in a much cheaper material. In addition, the clad material has better fatigue strength than ordinary steel. It can be fabricated by the

welding, cutting, and forming processes suitable for stainless steel. Originally developed for applications in the chemical process industries, the stainless-clad steels are reaching out for structural uses as well and are sure to find employment ultimately in building construction, automotive components, and railway equipment as well as widely increased use in the chemicals, oil refining, rubber, paper-processing, and related fields.

Similar to stainless-clad but more specific in their serviceability are nickel-clad, Inconel-clad, copper-clad and even admiralty-metal-clad steels. These are mostly designed for and will be ultimately used in chemical processing. One manufacturer has brought out a line of duplex tubes that are simultaneously good for two corrosive environments —one on the inside of the tube and the other on the outside.

CAST COMPOSITE — One of the most significant of recent developments in the composite materials field is the Al-Fin process in which aluminum or an aluminum alloy is integrally joined to steel, iron, or other base metals by casting the light metal in the usual manner against a specially prepared steel or other surface. This particular combination combines the heat-dissipating ability, light weight, conductivity, and corrosion resistance of the aluminum alloy with the strength and hardness of the ferrous metal.

Developed originally for airplane cylinder barrels (the aluminum muff and fin structure removes the heat from the steel barrel around which it is cast) the Al-Fin process and product can rely on other advantages (for example, the excellent high-temperature oxidation resistance of aluminum and its good bearing properties) to make them suitable for such diversified uses as radio transmission power tubes, airplane exhaust stack heat exchangers, bearings, and composite gears.

Indeed it has been characteristic of the two-in-one materials that the purposes for which they were originally devised in each case have been "only the beginning," and they have gone on to many new applications in fields undreamed of by their original developer.

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WELDING DISTORTION

Can Be Cured by Finding Causes

WELDING will play an important role in America's industrial future as a means of fast production and in making possible the streamline designs that engineers are projecting for many consumer and industrial goods of tomorrow, says Charles H. Jennings, welding authority with the Westinghouse Research Laboratories. This engineer terms distortion as one of the major problems of welding. He explains that the heating and cooling of the metal within the area being welded, and the contraction of the filler metal during the cooling period cause the fabricated structure to shrink or warp.

"However," Mr. Jennings continues, "by properly studying the fundamental factors producing distortion and applying corrective measures—such as clamping the parts in fixtures during welding, pre-distorting the parts to compensate for expected distortion, or developing special welding techniques—distortion can often be held to a very low point or entirely eliminated.

COPPER TUBING

Is Finding Increased Use in Factories

THE FAMILIAR advantages of copper or brass tubing that have led to its use for house water lines are beginning to be recognized by plant men and engineers and should lead to its increasing use for water, air, oil, and hydraulic lines for factories.

For industrial water lines, copper tubing with solder-joint fittings not only outlasts rustable piping several times but also is lighter in overall weight and more convenient to install.

WELDING HAZARDS

Proved to Be Largely Mythical

ARC WELDING is the victim of more unjust or exaggerated charges of danger to health or safety than any other metal-working operation, and a recent investigation has scientifically laid many of them to rest.

Thus it is definitely untrue that most arc-welding equipment gives off "mystery" radiations that may cause sterility or other strange ailments. At General Electric's Schenectady plant, welding operators have carried pieces of photographic film around in their clothing for weeks at a time without any evidence of X-ray-like radiation appearing.

Again, a survey of four manufacturers using arc welding showed that they employed a total of 14,475 industrial workers and suffered a total of 13 fatalities in one year, or an average of one death per 1100 workers. Included in these totals were 1125 arc welders, among whom there was one fatality.

Obviously, the electrical shock hazard in arc welding is no greater than the normal hazard in industrial work in general.

MAGNESIUM ALLOYS

Are Not Potential Fire Hazards

THE GREATEST factor curtailing the wider application of magensium alloys has been the common misapprehension that these alloys are inflammable.

This ghost has been scientifically laid to rest by Louis A. Carapella and Wm. E. Shaw, of Mellon Institute, who conducted tests on a number of magnesium alloys to ascertain their behavior on direct exposure to fire. It was demonstrated beyond question that *solid magnesium alloys do not burn.*

Melting must occur before burning can take place, which means that ignition cannot possibly occur until the metal reaches temperatures from 840 to 1500 degrees, Fahrenheit. Massive magnesium does not reach such temperatures easily, either, because of the relatively high heat conductivity of the alloys. Furthermore, burning need not occur even when handling the molten metal, for with simple precautions alloy-making, metal-refining, pouring, casting, and welding are widely performed without trouble.

POROUS CHROME

Is Successful in Prolonging Life of Engine Cylinders

AN EXAMPLE of how successful porous chromium plating can be in lengthening the operating life of engine cylinders to which it is applied has recently been reported.

A merchant ship whose main Diesel-engine cylinders were porous chromium plated ran for five years and traveled 300,000 miles before the chromium had worn enough to require reprocessing. At one time the engine was submerged in seawater 14 days before the ship could be salvaged.

Porous chromium plate differs from the usual chromium plate in that its surface is covered with tiny pits or small channels which effectively retain lubricating oil. While its use is steadily increasing on ship Diesel piston rings and cylinders, this type of plating has operating advantages that are also of special interest to makers and users of auto, truck, and railway engine cylinders as well as for cylinder surfaces in hydraulic equipment, pumps, and so on.

What new "armor" for steel can save America millions each year?

YEAR AFTER YEAR—in war or peace—America pays a colossal toll in dollars to a foe as unrelenting as any ever known.

It is the enemy *rust*, that attacks and destroys things made of steel. But now a remarkable new discovery can bring you steel products that will *defy* rust up to 4 times longer . . . Hardware, screens, fencing, automobiles, tractors, dozens of important items that will outlast any you've ever owned by as much as 4 to 1!

This remarkable discovery is CORRONIZING, the patented alloy "armor" that gives steel a new lease on life. Yes, CORRONIZING is new . . . but also thoroughly tested and proved. For CORRONIZING has demonstrated its overwhelming superiority in the war, under the worst possible conditions on land, at sea and in the air.

By test and performance, CORRONIZING FAR OUTLASTS OTHER PROTECTIVE COATINGS FOR STEEL. Now, the more progressive factories and retailers will be able to bring you products made of "Corronized" steel. Motor car makers—always leaders—will be among the first to offer you this sensational advantage.

Remember that name—CORRONIZING. It can save you and millions of other Americans a huge tax bill now needlessly paid to the enemy rust.

Standard Steel Spring Co.

ORIGINATORS OF

CORRONIZING



CORRONIZED
For Enduring Protection
Against Rust

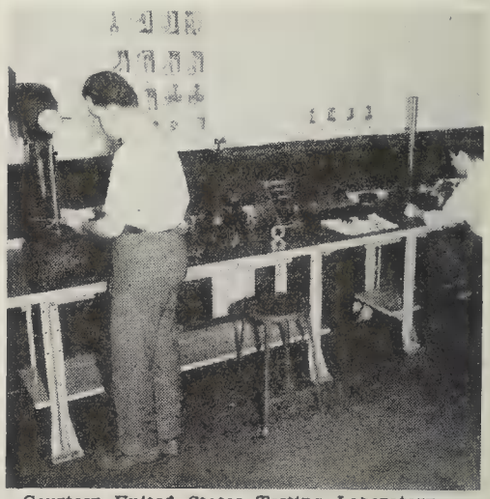
Quick Facts for Manufacturing and Sales Executives

Do not confuse CORRONIZING with other metal coatings. This patented process provides a permanent alloy "armor" with 5 layers of defense against corrosion! It becomes part of the steel base . . . can be worked in any manner. Permits using lighter materials by prolonging steel's period of greatest strength. Write for samples and complete information.

STANDARD STEEL SPRING COMPANY
CORAOPOLIS, PENNSYLVANIA

Research For Small Business

A Little Research into Effective Means of Utilizing Research Reveals that Small Businesses Can Put Themselves on a Par With Big Business By Making Use of Available Facilities. Government Research Must Benefit All and Hence Must Fail in at Least One of its Avowed Purposes



Courtesy United States Testing Laboratory
Materials testing

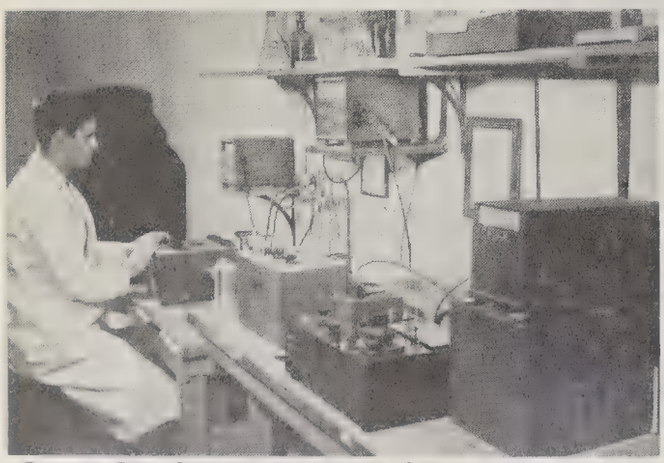
As THE story of industrial progress during the war years is gradually uncovered, tremendous forward strides are revealed. Basically, this progress has depended on the development to commercial usefulness of scientific research for a long period preceding the war. This again emphasizes research as the stuff of all progress; that industry must build on science. As has been truly said, man has come to live in a fourth kingdom, a synthetic kingdom, cognate with the animal, vegetable, and mineral kingdoms of his childhood. This synthetic kingdom is clearly a creature of research, of science put to work, of the abstruse concepts of science materialized into the work-a-day things of modern living.

No longer is it possible for any business or industry to ignore science. Research has of necessity become an integral part of all civilization. There can no longer be any argument about its value. The only question that can now properly arise concerns the types of research appropriate to a particular enterprise and when and how these may be obtained.

Research—in the chemical field or elsewhere—is the method of discovery and invention. It stands out as a dominant force in war. It is equally vital, though less spectacular, in peace. Its immense value has been stressed and explained to greater and greater numbers of people through extraordinary research achievements of the past five years. Quite naturally it has attracted political attention and pressure has been applied to put our paternalistic government into the business of supplying research facilities to those who presumably cannot afford it for themselves. The idea is to help the small business man by providing research for him, at taxpayers' expense, thus giving him an advantage comparable with that enjoyed by big business. That is a perfectly good idea and a laudable objective, but it can only be made to work by observing and considering the peculiarities of research itself.

Considering the significance of the place research occupies in the world, it is amazing how little is actually known about it by otherwise well informed business executives. Where to go to get research for one's business needs, what types of research one should engage in, and even what research is; these and like questions apparently vex many intelligent business executives and impede their progress toward that Utopia which research is expected to open to business and industry.

It will be worth while to look into the whole subject because of the danger, already apparent, that research may become a political issue. Not that a thinking person can be of two minds as to its fundamental value, but rather that handling of the mechanics of research in the customary political manner is sure to entangle the main proposal with useless and complicating appendages having little or no relation to the main theme. It even seems likely that the anticipated benefits may become lost in the tangles of red tape. Therefore it behooves thinking persons to become familiar with the subject in order to be able intelligently to decide the issues likely to require decision soon.



Courtesy Food Research Laboratories, Inc.

The chemist in the research laboratory of today seldom stands at a window peering through a test tube. More often he is found at a table such as this one, making use of photoelectric and other precision equipment

RESEARCH DEFINED—Research resembles food which must undergo subtle changes within our bodies before it can be absorbed and become an actual part of us. The pangs and perils of overloaded digestions are common experiences. And it is scarcely necessary to emphasize that all foods are not equally suited to all digestions. Picture a rabbit wolfing a beefsteak, for instance, or a lion nibbling a lettuce leaf! Research, which, is a mental process and deals with ideas, is like that. Too much research, particularly too much successful research at one

time, can bankrupt a company quite as surely as too little. It is also true of research that to be useful it must be directed toward ends compatible with the abilities and aims of its expected beneficiaries.

We must recognize as types of research both the search for new knowledge for its own sake alone that characterizes the purest of research and the extremely valuable application of acquired knowledge to new situations and combinations. These are distinguished by the newness of the knowledge acquired and by the novelty of its applications from the repetitious and more or less mechanical operations of testing and analyzing products. The scientific speculations, experiments, and observations which led up to the idea that vast amounts of energy could be released from atoms by bombardment with neutrons clearly belongs to the first phase of research. The second phase is equally well illustrated by the development of methods, mechanisms, and materials to apply this basic principle to a military weapon. During the course of both phases of this incomparably important research almost countless numbers of more or less routine analyses and tests had to be made in collecting information necessary, but subsidiary, to the main objectives. This last belongs in a category that may at one time be definitely research and at another quite as definitely outside of that class. The distinction is based on the purpose for which the tests are conducted.

For present purposes, then, research is the search for new knowledge, facts, and combinations in whatever field and for whatever purpose. Physical entities alone are the concern and hence researches are conducted by the experimental method of the physical sciences. That greatly narrows the definition but it still covers an immensely wide territory, excluding only certain activities sometimes falsely called research which are simple searches for information known already to exist.

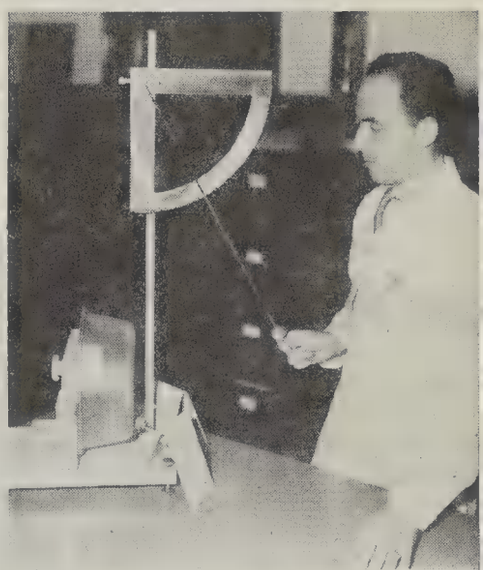
"FOCUSING" RESEARCH—While it is obviously true that no research is worthy of the name whose result can be known in advance, yet it is always necessary to direct and control the progress of an investigation so as to bring its probable result within a limited area. In other words, it is possible, as well as necessary, to "focus" research. This is an essential of fruitful research. Whereas it is entirely proper for an academic group in a university alone to pursue a search for knowledge for its own sake alone, without serious thought as to its possible economic value, this is quite out of the question for most commercial enterprises. Such abstract research may also be conducted by government agencies.

Endowment of such pure research is sometimes provided by the earnings of industry and certainly industry can sometimes profit by such investigations, but only in rare circumstances can industry itself afford to carry on such excursions into knowledge for its own sake. Notable exceptions were the researches of Irving Langmuir and others in the laboratories of the General Electric Company into atomic structures, high vacuums, surface chemistry, and related matters which ultimately materialized in tremendous economies in electric lighting, among other benefits.

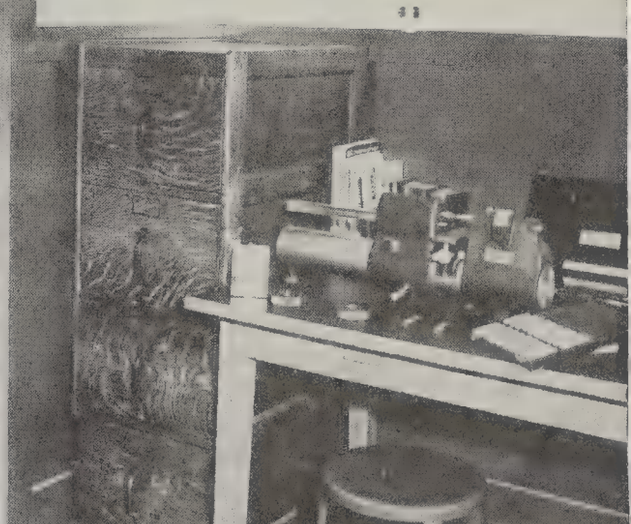
Very few corporate groups are able to engage directly in such pure researches because of lack of focus on specific problems. Hence, most businesses confine their efforts more particularly to what may be called the next circle of research. Leaving such purely theoretical investigations to the universities and other purely academic groups—defined as unconcerned with economics—the usual business research accepts the findings of the academic groups and applies them to specific problems either existing or likely to arise through expansion. The research group may be part of the organization, the common situation with big business, or it may be a specialized group employed for this sole purpose but maintaining a quite independent existence.

GOVERNMENT RESEARCH? — Those who would provide research for small business at taxpayers' expense overlook several essential aspects of the general problem. While the objective is to put little business on a competitive par with big business, merely providing the results of government research cannot affect the competitive situation. Proponents of the plan overlook the fact that no governmental activity can, by its very nature, confer a competitive advantage on any group but must, on the contrary, be equally available to all—big and little alike. This basic fact requires that any governmental research be conducted primarily on the plane of pure theory—designated as academic research since it must ignore economic considerations. In other words, the research that can be conducted by governmental agencies requires that

Below: Precision equipment in a modern laboratory. Right: Using an impact testing device on a glass bowl



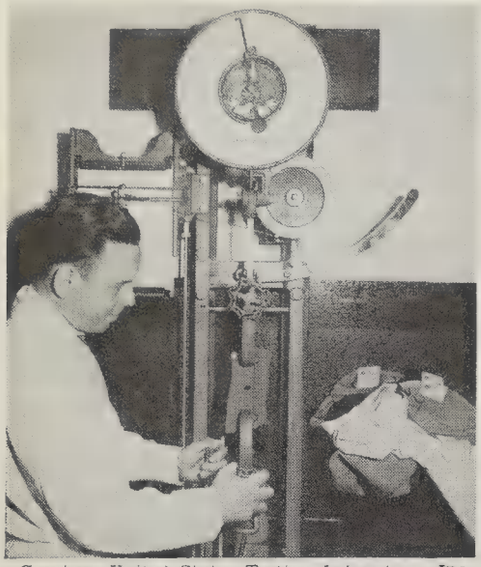




Courtesy United States Testing Company, Inc.

the beneficiary be able to adapt its findings to his own problems.

This is an important requirement and one that cannot be ignored. The mere application of economic considerations to the findings of academic research makes a vast difference in both its value and its cost. Redman, past president of the American Chemical Society, investigated the relative costs of researches and their applications some time ago and found that the cost



Courtesy United States Testing Laboratory, Inc.
Checking strength of cloth

of *applying* the research was roughly ten times the original cost of the research. In other words, government research will on the average cost the beneficiary some ten times its own cost after he has applied it to his operations before he begins to draw profits from it.

All this applies to the broadest view of research and neglects another vital aspect of the problem, mentioned above—the focus of research. A small business necessarily has problems, as does a big business, but they are usually of a different nature and certainly of a different order of magnitude. Even given the research organization and activity of a big business, a little man would surely find himself bankrupted in attempting to utilize it. On the other hand, the small business can profit substantially from researches planned for him and directed at his particular problems.

To illustrate: The researches on atomic fission, mentioned above as leading to the atomic bomb, can have no more than a most casual interest for any but the largest business groups. On the other hand, as parts of this stupendous project, numbers of subsidiary researches could properly interest even small businesses. A number of chemical elements and their compounds, not otherwise common, are required in certain kinds, purities, and quantities in some of the operations connected with the production of the bomb. Researches on these subjects ultimately led to methods that could be applied on reasonable scales by companies in the smaller ranges of big business. Numerous other subsidiary projects suitable for small business have resulted from the prosecution of other major campaigns on larger objectives. The growth of a small company making the instruments developed and needed by a large research organization is quite typical of this kind of thing.

CONVERTING IDEAS — The essential point is that the small business must be in a position, within its available means, to convert the ideas developed by its research into profitable activity. This aspect of research seems neglected by the busy planners who would use taxpapers' money to create research facilities to put small business on a par with big business already organized to conduct its own research. Clearly, the competitive advantage which each small business (or large one) seeks through research can only be gained by the exercise of private enterprise which will center its attention on an attainable objective and which will further hold the results obtained in a satisfactorily confidential status.

Small business needs a certain guidance in this matter which has been lately supplied by Major W. P. Putnam, President of the American Council of Commercial Laboratories. Major Putnam, himself head of an important laboratory, points out that it is quite possible, and highly advantageous, for a small business to entrust its problems that can be solved by research methods to highly skilled scientists in well equipped independent commercial laboratories. Furthermore, the extent of any research can be established in the beginning so that the business man can limit his expenditure to any amount that may seem to him desirable, whether it be a hundred dollars or a thousand or many times that amount.

Frequently, too, the need of the small business may not involve research as it has been defined, but rather may be the simple and direct application of known principles of science or engineering to solve a given problem. The wide experience available in America's independent consulting laboratories also provides this kind of service at the lowest reasonable cost to the client.

In these independent laboratories, themselves small businesses, already exist research organizations for other small businesses far more effective for their purpose in a competitive world than government research could be. Obviously, small business has an important asset here that must be recognized.

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DISTILLER'S GRAINS

Waste Contains Many Nutriments

Alcohol distillers use only the starch of the grain; the waste contains the original protein, fat, and vitamins of the grain, plus any additions, particularly vitamins, made by the growing yeast. This aspect of the alcohol industry has lately been emphasized by distillers in an effort to obtain more leniency in the war-imposed restrictions on their operations and raw materials. One pound of corn distillers' dried grains will replace 3.7 pounds of corn in balancing the ration of beef animals. The high protein content of the recovered grain is important.

CABLE SPEED

Increased by Use of Polythene Plastics

Higher speed transmission is reported for submarine cables in which the customary gutta-percha insulation is replaced by the new polythene plastics developed during the war. British cable operating companies are said to be actively prosecuting the development of the new insulation for this purpose. Plants for producing polythene plastics are being expanded in the United States.

CANNED ARMS

Are Involved in Huge Protection Project

What is probably the largest canning project ever undertaken is being carried out by the Ordnance Department of the United States Army. The purpose is to preserve the guns, instruments, and other intricate units made for the late war against any possible future need. Many types of drums, specially constructed containers, and plastics layers are under investigation or in use. The objective is to prevent access of air, moisture, light, and other possibly destructive agencies that might damage expensive products.

Economics of Electronics

Much of the Enthusiastic but Misguided Publicity Given to Electronics May Prove a Boomerang to Acceptance of Really Worthwhile Developments. Uses of Electronics, Especially in Manufacturing Techniques, are Almost Unlimited, but Require Careful and Responsible Development

By JOHN MARKUS
Associate Editor, *Electronics*



An excellent example of an economically sound electronic application is this Westinghouse photoelectric safety system that prevents the metal-cutting shears from descending when workmen's fingers are in blade's path

AMONG recent additions to the long parade of electronic inventions is an electronic rat trap that operates when a rat passing through an open tunnel cuts an invisible ray beamed on a phototube. Electro-magnetic latches, energized by a photoelectric amplifier, drop trap doors at both ends of the tunnel. The bewildered rat, seeing light only above him, goes up a ramp to a small chamber where he steps on a switch plate. This turns on a current that electrocutes him.

The rat trap just described would undoubtedly catch rats, and might also be technically satisfactory, but it is certainly not a good idea from an economic standpoint because such a device would cost way over ten dollars, even in mass production, and good rat traps can be bought today for a dime apiece. Electron tubes can and do accomplish wonderful things, but the electronic industry cannot exist on the glamour or publicity value of the job it is intended to do.

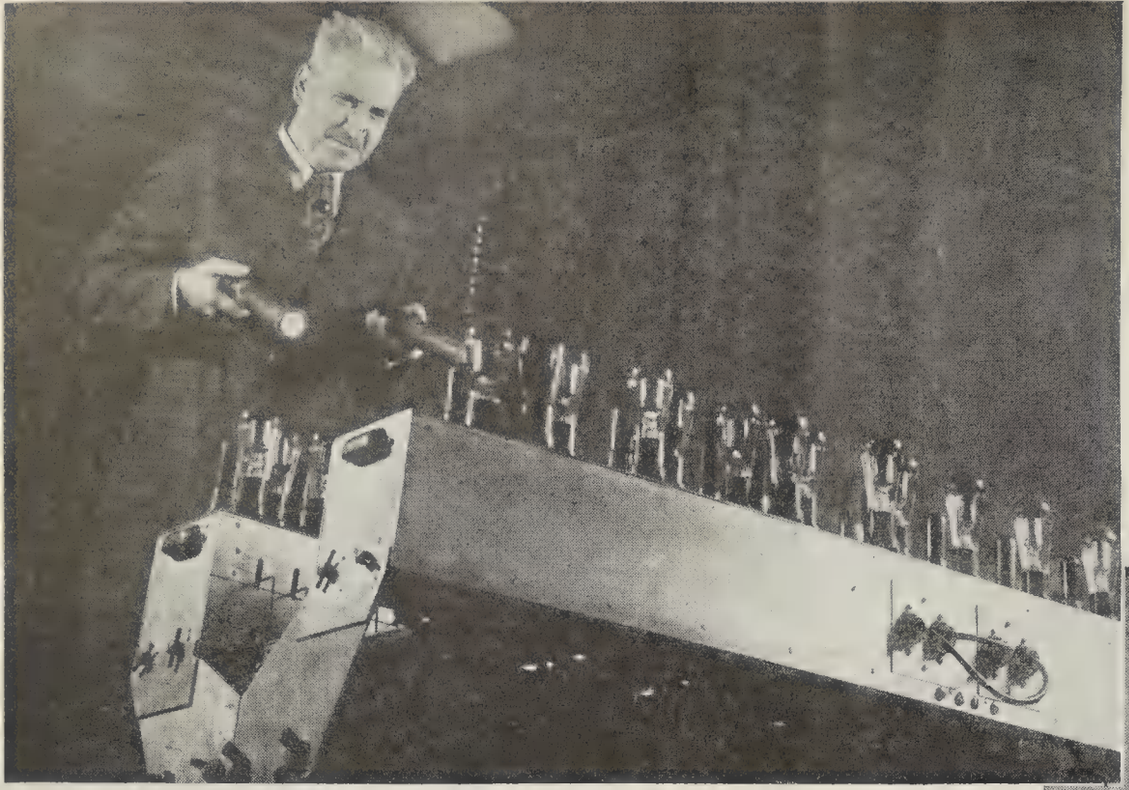
During war-time the manufacturers of munitions and ordnance devices knew that their tremendous volume of business was due solely to war demands. The same was true of the aircraft manufacturers. Far too many electronic manufacturers are hoping, however, that somehow or other the huge war-time demand for electronic equipment will be converted into nearly the same volume of peace-time electronic business, possibly on the much-publicized premise that we have entered the new era of electronics.

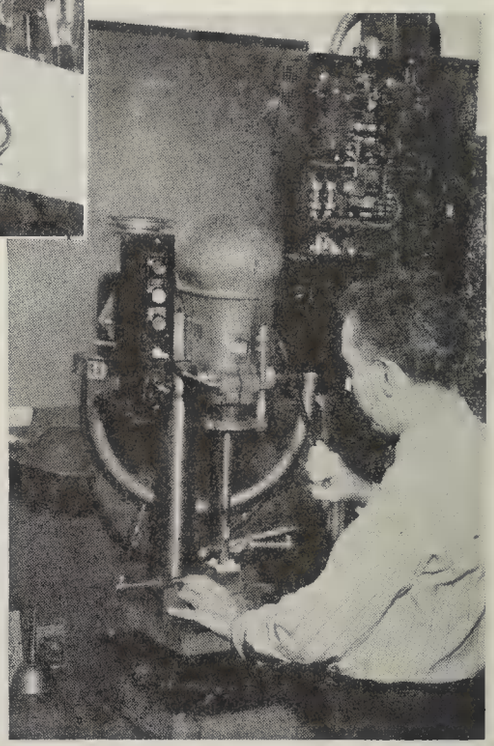


Electronic timing and control are combined in this General Electric heat-treatment equipment for surface-hardening gears. All the operator has to do is handle gears and press buttons

What the layman sometimes forgets is that military electronic requirements were necessarily inflated far beyond that of corresponding peace-time requirements. The useful life of electronic equipment in war-time is necessarily much shorter than its obsolescence life in normal use, due to vibration and concussion in combat and rough handling during transit and storage in all corners of the globe. Commercial electrical equipment is capitalized on a basis of 10 to 20 years, whereas the life expectation of radio equipment in war-time is probably more like 10 to 20 months, if not weeks.

A second factor in the war-time electronics picture is the large number of spare parts that were manu-





The electronic marimba (left) is interesting but not a good bet economically. On the other hand, electronic motor controls (below) speed up operations and exemplify good engineering practice

factured for each piece of military electronic equipment. Tanks, planes, and ships had to be used and serviced in huge numbers in hundreds of widely scattered localities. Therefore, spare parts were produced and distributed so they would be available when and where needed, in a ratio far exceeding that required for normal or peace-time electronic devices.

SALES APPEAL—The glamour attached to electronics unquestionably adds to the sales appeal of a product. This is due to the blaze of publicity that electronics has received and because of its winning role in the war. Unfortunately, however, electronics has been overpublicized. The marketing of electronic devices that are either involuntary or deliberate fakes, doing a job no better than cheaper mechanical or electrical equivalent products, will harm and discredit the electronic industry. For the industry to prosper, its products must possess definite advantages in greater efficiency of operation or must do things that have never been done before.

Electronic heating, as an example, meets both requirements. It heats and dries materials faster and more uniformly than older steam, gas, or electric methods and it has a high score of never-done-before achievements. Here the future is legitimately bright, and every alert businessman should investigate the possibility of applying this war-time-mushroomed electronic technique to improving his own products. The extent of industrial electronic heating today is clearly shown by a report of a recent survey which lists over 125 different models of induction and dielectric heating equipment made as standard packaged units by 15 different manufacturers, and still more firms offering custom-built units for special applications.

Applications for high-frequency heating are divided into two distinct groups: (1) induction heating units for melting, hardening, brazing, soldering, and heat treatment of metallic and conducting materials, and (2) dielectric heating units for heating, dehydrating, sterilization, or cooking of non-conducting materials such as tobacco, wood products, food, cereals, and other agricultural products.

Electronic heating is expensive, though—even more than electric heating—because the tubes that convert the ordinary 60-cycle power into high-frequency power are expensive and are not 100-percent efficient. Here, as in every other electronic application, the initial cost, power cost, and maintenance cost must be compared to similar costs of other methods and the result balanced against the advantages of electronics before making a decision.

Reacting almost instantly to a change of condition is another role in which electronics shines, and this characteristic of vacuum tubes lends itself admirably to electronic control of machinery and processes.

FASTER AND BETTER—Welding timers were the first large-scale and exceedingly successful industrial application of fast-responding electronic control circuits. The task of the welding timer consists of delivering to the welder transformer powers running into hundreds of kilowatts but only for a short period of time. Electronic timing is indicated because it is extremely difficult to devise mechanical or electro-mechanical timers to handle the large current with sufficient accuracy and without rapid deterioration of contacts.

Another important advantage of electronic control is high sensitivity combined with the ability to do useful work such as operating relays. A fine galvanometer can move a pointer or deflect a light beam up the scale, but nothing more. If the power for a furnace is to be started or stopped as directed by the galvanometer deflection, the position of the galvanometer pointer must be translated into the desired action.

The modern link between a galvanometer pointer and a contactor or an electric motor is an electronic device that is controlled by the galvanometer and yet adds no load to the galvanometer. Photoelectric systems are often used for this purpose.

The third advantage of electronic control is its suitability for remote control. Electronic links can be op-

erated over almost any desired distance with conventional wiring, and now even radio links can be used. Thus, the readings of the altimeter and other instruments in a pilotless plane can be transmitted to duplicate instruments on the ground by radio and read there.

One other major point of superiority is the flexibility of control design. The variety of tubes and other circuit elements available is almost as great as the number of combinations in a chess game, so the electronic control can be given almost any characteristics. It can be fast, or time delays may be readily incorporated. It can be rugged and sensitive at the same time.

Electronic control of D.C. motors is a major industrial application of electronics. In response to electronic, electrical, or mechanical monitoring devices, tubes can regulate or change the speed of the motor in the required manner.

DELICATE SENSING — Electronic links have been extremely useful in stopping or starting some or all operations on high-speed machines where mechanical methods become awkward or impossible. If, for example, a delicate sensing device is needed to start, stop, or control heavy equipment, an electronic link will probably do the job better than anything else. An electronic device may, for instance, be designed to follow up the movement of an instrument pointer and perform almost any control function, either near the instrument or miles away from it. One interesting application is to the automatic cutting torch, which reproduces the pattern of a template without touching it.

Electronic devices for the inspection of metals for uniformity, soundness, and size are in use in many places. Devices of this type may reveal cracks, slag inclusions, voids, changes in chemical composition, results of faulty heat treatment, and under- or over-size. The devices are nondestructive and very fast. Old style tests sometimes destroy or mar the test pieces and are much slower, so here electronic techniques are advantageous.

Many electronic devices sold to industry have ended in the factory morgue or curio cabinet after a six-weeks trial. Such devices were too difficult to use, or required too much supervision and maintenance.

Reliability is essential for industrial use. A 10 percent variation in the output of a radio receiver over a period of time will be barely noticeable, infrequent clicks being ascribed to static, but such variations in industrial devices might cause spoiled products or even loss of life.

This does not mean that electronic devices are less reliable than their mechanical and electrical brethren. It means only that electronic devices require more ingenuity and meticulous care in design before they are manufactured and released for use.

Truly, industrial electronics is as replete with opportunities as it is beset with traps for the unwary. Anyone who looks into a crystal ball and sees electronics doing most of the work in the homes and factories of the future should have another crystal ball handy, into which he could peer and determine the date when these marvelous developments will become available to customers.

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MILLISECOND TIMER

Can Be Used for Test and Experimental Applications

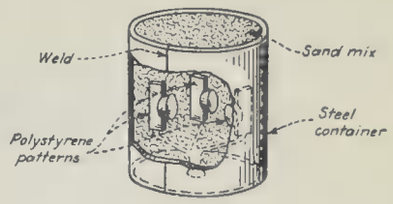
OPERATING on momentary impulses of extremely short duration, a new millisecond timer is designed for use in factory test departments and experimental laboratories. Among its industrial applications are the measurement of pull-in and drop-out timing of high-speed circuit breakers and relays, and timing of other high-speed operations.

The complete timer assembly comprises a millisecond timer movement and an electronic control chassis. The timer movement is driven by a 115-volt, 60-cycle synchronous motor of the high-speed shaded-pole synchronous type. The movement drives two hands over a dial that is calibrated in units of 0.0002 second and totalizes to six seconds before repeating. The faster hand is driven at a speed of 600 rpm. The timer movement is capable of resetting the hands to zero from any position by the manual operation of a reset lever or knob. The unit is made by Standard Electric Time Company.

STYRENE PATTERNS

Removed From Molds by Melting

CENTRIFUGAL casting of intricate steel parts produces accurate castings requiring no machining. One of the major problems, however, is that of getting the patterns out of the sand mold without dislodging sand and thereby destroying the fine details of the casting. In the recently developed electronic solution to this perplexing problem, a heavy sheet-metal cylinder serves to enclose the molding sand, and a polystyrene pattern is used instead of wood. The styrene is melted out by induction electronic heating applied to the metal cylinder, after which



Induction electronic heating speeds up melting of polystyrene patterns

the molten metal is injected into the cavity by centrifugal force.

A slow rate of heat of the styrene pattern is required at the start to prevent excessive moisture and alcohol in the sand mix from exploding the mold. On one set of samples, submitted to Commonwealth Edison Company engineers, the ideal seemed to be four one-minute cycles separated by one-minute intervals. The method formerly used required from 1¼ to 1½ hours to melt out the styrene.

BALL SORTER

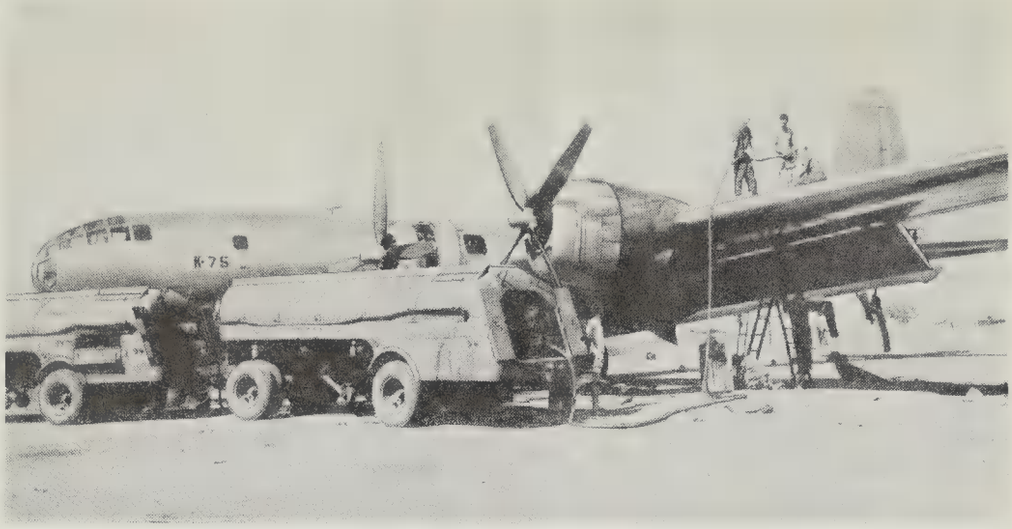
Employs Electronics for Extreme Accuracy

HIGHLY polished steel balls, all within 1/20,000 of an inch of the same size, are sorted into groups of as many as ten size selections automatically by an electronic gage de-



Steel balls from the hopper roll down the incline; metal fingers in vacuum tube circuits sort them automatically

veloped by Jack and Heintz, Inc. The balls in any one group then differ in diameter by only ten millionths of an inch, a precision more than adequate for the finest ball bearings. One operator can handle four machines easily, and these will sort more balls than 32 skilled operators could do with conventional measuring equipment. The operator merely fills the Plexiglas hopper, and removes the sorted balls from their individual containers a few seconds later. Vacuum tubes connected to contact fingers sort the balls.



A Heil mobile refueling unit saves time and trouble

AVIATION Conducted by ALEXANDER KLEMIN

Flying Aids

Aviation Gas Stations—Complete With Fuel, Oil, and Information Service—Offer Increased Safety and Convenience to the Pilot. A Number of Combination Automobile and Aircraft Stations Have Their Own Flight Strips. Fire-Fighting Equipment Adds to Overall Safety

MANY an old-time pilot recalls with mingled feelings the day when to take up a plane for even a short cross-country hop was very much of an adventure. Once safely off the rough flying field, often just missing the boundary fence by inches, he climbed slowly above the tree tops and silently prayed that his engine would not start missing on half its cylinders. Always he kept his eyes open for possible emergency landing spots—an open field, a golf course, or a rambling estate, where he was sure to find a welcome from the owner if he developed engine trouble and was forced to land. Barring a sudden rainstorm, or unexpected ground mist, he arrived at his destination safely and climbed out of his plane with a feeling of genuine relief. The local garage would supply him with gasoline of sorts, filtering it through a chamois cloth which the pilot wisely carried in the plane with him. And if he needed any minor repairs to his plane, which frequently was the case, the garage mechanic would set to with what tools he had available. Happily—those days are gone forever.

Today a pilot takes off knowing that his engine will not stop just as he rises from the smooth airport. And as he gains height he can see, within easy gliding distance, not one, but perhaps several well kept airports. And he can be informed beforehand that the weather at the airport where he plans to land is clear, with no rain or fog hiding it from view.

Flying today, thanks to the intelligent co-operation of every one connected with flying, from the oil companies to accessory manufacturers, is rapidly becoming not only a pleasant pastime but, to the busy executive, an invaluable time saver.

Profiting by its many years of experience in assisting motorists who purchased gas at its roadside filling stations, Standard Oil Company (New Jersey) has prepared a small plastics Flight Data card which it gives to every pilot who gasses up at an Esso station. In addition, the company provides him with whatever flying information he may require such as the latest reports concerning weather ahead as well as other flying aids to insure his safety.

BETTER FUELS—There are many other ways in which the oil companies are helping flying in general and private flying in particular. They are making available to the private flyer 80-octane gasoline which is really as high a fuel rating as the current makes of engines in private flying require. In fact, they are making an effort to create universal acceptance of 80-octane gasoline for private flying. Some privately owned aircraft of the executive class having engines exceeding 450 horsepower may require 91-octane and will get it. The best fuels will now be available to flying generally and not to military and naval flying only.

The roadside gas service station has in many respects become the equivalent of the old coaching inn. The service station is the place where the motorist stops off and seeks refreshment for man and "beast," only his beast is a mechanical one. In the aviation gas stations are also clean rest rooms, attractive merchandise displays, and a lounge where flyers may rest. Motorists have long used credit cards valid all over the United States. Esso is planning international credit cards for aircraft owners that will be good all over the world. In addition to the pilot's flight data card described previously, he will be given quick

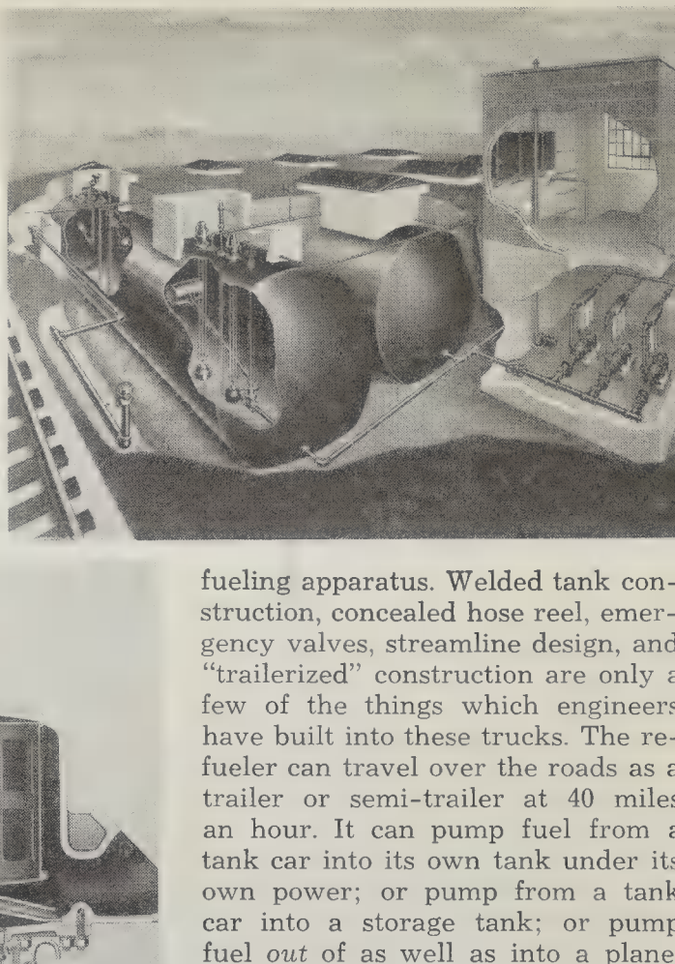
calculators for estimating distances, fuel consumption, and so on.

The oil companies have also undertaken to educate the flying public in matters of lubrication, quite as thoroughly as they have done in regard to the lubrication of the automobile. One oil firm has prepared a fine "check-chart" for airplane lubrication. No part of the airplane is left unnoticed. An arrow leads to such parts as Elevator Tab Drive Drum Bearings; Tail Wheel Shock Strut; Aileron Hinge Bearings, and so on. For each moving part the proper lubricant is indicated, together with the appropriate lubricating interval in flying hours. The same chart carries practical instructions for filling shock struts and fuel tanks. Such a chart is an indication of the fact that private flying is becoming as frequent and almost as common place as automobiling. Will the oil companies issue flying maps, like the maps which many motorists treasure in the pockets of their cars? Not as yet. They do not wish to enter into competition with the complicated aerial navigation charts which the United States Coast and Geodetic Survey issues twice a year.

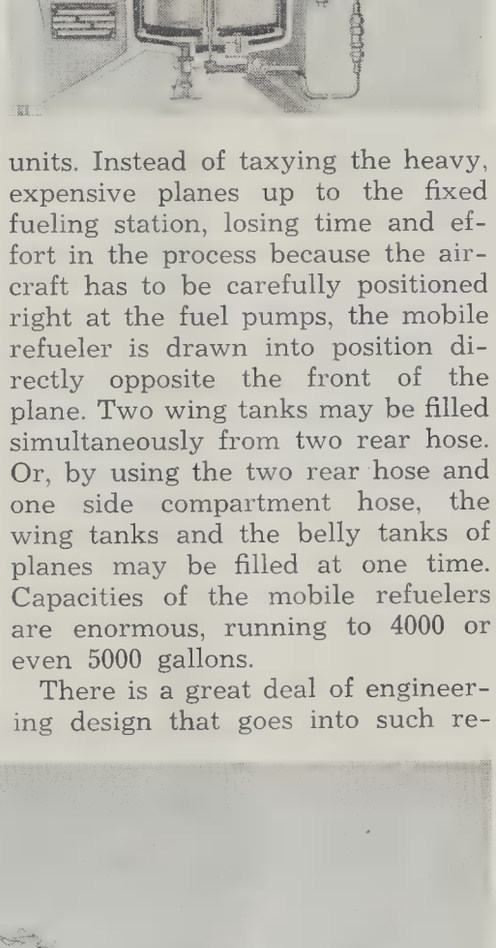
Considerable thought is being given to the development of combination roadside automobile and aircraft service stations, with flight strips laid out behind the service station. Several of these have already been established. As private flying increases in volume, the flight-strip gasoline stations will also increase in number.

MOBILE FUELING — Manufacturers of accessories are co-operating in many ways in the common task of aiding civilian flying. An example is in the provision of mobile units for rapid fueling and servicing of airplanes. These units are very popular and the greater percentage of aircraft fuel today is pumped from tank trucks or trailers into aircraft fuel tanks. The Heil Company has done much pioneering in such

Right: Partially cutaway view of a flooded suction system for gasoline storage and delivery at an airport. In this Bowser Company set-up, the pumps are located below the level of the tanks



Below: Cross-section of a water and gasoline segregator developed by Wright Field



units. Instead of taxying the heavy, expensive planes up to the fixed fueling station, losing time and effort in the process because the aircraft has to be carefully positioned right at the fuel pumps, the mobile refueler is drawn into position directly opposite the front of the plane. Two wing tanks may be filled simultaneously from two rear hose. Or, by using the two rear hose and one side compartment hose, the wing tanks and the belly tanks of planes may be filled at one time. Capacities of the mobile refuelers are enormous, running to 4000 or even 5000 gallons.

There is a great deal of engineering design that goes into such refueling apparatus. Welded tank construction, concealed hose reel, emergency valves, streamline design, and "trailerized" construction are only a few of the things which engineers have built into these trucks. The refueler can travel over the roads as a trailer or semi-trailer at 40 miles an hour. It can pump fuel from a tank car into its own tank under its own power; or pump from a tank car into a storage tank; or pump fuel *out* of as well as into a plane. Fuel meters and fire extinguishers are also part of the equipment.

A highly important part of the refueler's equipment is its segregator which automatically compensates for variations in gasoline and removes any water which may be present. It is based on the simple principle that water and gasoline have different specific gravities. The segregator developed by Wright Field engineers, has a float valve which is balanced to float in water and sink in the lighter gasoline. When the water accumulating in the segregator bowl rises to a point where it lifts the float valve, the water is automatically discharged to the outside.

Experimental work is in progress in the use of pressure filters for the removal of not only water but of all solids down to specified measurements. These filters are made up of paper or fabric packs, and the degree of purity is governed by the number of packs and the degree of pressure used. The solids accumulate directly in the packs which have to be periodically changed or cleaned. Water is passed off either automatically or manually at the bottom of the filters. Air is eliminated by means of an air release, the air rising to the top of the filter where it is accumulated and automatically passed off.

But if the mobile airplane refueling unit is considered a remarkable piece of engineering, the fueling system at some airports is a revelation to the uninitiated. Growing airplane traffic and gasoline con-



Fire-fighting at an airport with a Cardox crash truck

sumption necessitated underground fuel storage and motor driven pumps as early as the 1920's. The first system installed consisted of an underground storage tank, an electrically driven rotary pump, centrifugal strainers, and a pipe line to an underground pit containing a meter and hose mounted on a hand-operated reel. Since those days, many new developments have come, and the Bowser Company has developed many fueling refinements. Rotary pumps have largely, for many reasons, been superseded by flooded centrifugal pumps. These centrifugal pumps are located below the level of the tanks and the fuel flows to them by gravity to maintain the flooded suction condition. There are many valves, strainers, and other accessories, such as air and vapor eliminators in the system. Pumps are installed in an underground pump house. The system will deliver aviation gasoline at any desired point on the hangar apron.

FIRE PROTECTION — Until nonflammable safety-fuel comes into general use, the extinguishing of gasoline fires resulting from crash landings is a vital matter. The Cardox Corporation has given the AAF much valuable service in the development of fire extinguishing trucks, which are now coming into civil use. Fires due to a crash landing are the toughest of all to extinguish, fed as they are by hundreds or even thousands of gallons of aviation gasoline. The problem of extinguishing them is a surprisingly technical one. But the principle is simple, involving the discharge of tons of carbon dioxide, released at low pressure, (but with great rapidity and power) in combination with "foam" discharged at high pressure. The Cardox airport fire trucks have saved hundreds of planes and many lives. The mass discharge of carbon dioxide, supplemented by the blanket of foam, cuts a path to the heart of the fire so that the rescue of entrapped personnel may frequently be started within five to ten seconds after the truck reaches the scene of the fire!

FUTURE — Safe and comfortable private flying is already here. It is daily increasing in volume. With the cost of planes now within the reach of many, department stores in the larger cities are displaying and selling them. Thousands of young military-trained flyers are returning to civil life 100 percent air-minded. The future of civilian flying and related industries is assured. It remains only for more and far-reaching flying facilities to be developed to see airplanes rival the earthbound motor car in popularity and —what is more important—maximum safety.

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THE DC-8

Has Enclosed Liquid-Cooled Engines

THE AIRLINER most commonly seen for many years is the famous and sturdy Douglas DC-3. But the best of things must come to an end, and even the DC-3, splendid as its service has been, must give way to more advanced design ideas. There is no doubt that Douglas engineers have taken a long step forward in bringing out the new DC-8; they have been both original and bold in their conceptions.

In the DC-8, there are no engines in sight and the huge twin counter-rotating propellers are mounted astern of the fuselage. The two liquid-cooled Allison engines of 1200 horsepower each are mounted under the forward cargo compartment and drive the rear propellers through gears and shafting some 60 feet in length. It is a disadvantage to have so long a transmission system, but this disadvantage is more than balanced by the many advantages which the new power plant system has introduced.

Thus, the DC-8 has twin engine safety without the offset thrust which is such a nuisance on more conventional twin-engined aircraft. The "center-line thrust" is going to be very helpful in single-engine emergency flying. Because the engines are hidden inside the fuselage, the surface of the wing is beautifully clean, with greater aerodynamic efficiency and a better lift distribution along the span. Because the propellers are aft, the wing can be placed quite close to the ground, and this makes for easy entry of passengers and cargo into the fuselage. Again, the shorter landing gear saves weight. Because the propellers can be made large in diameter, take-off and climb are improved.

It has been said that Douglas will have many difficulties to surmount because of the long transmission system, but these difficulties should be well worth facing. And the specifications are very attractive. The new transport will have a payload of 12,000 pounds at 300 miles range, and will carry 48 passengers and 2400 pounds of baggage at 223 miles per hour. The direct operating cost per ton mile will be only 3.5 cents. Maximum gross weight will be 39,500 pounds and wing span will be 110 feet.

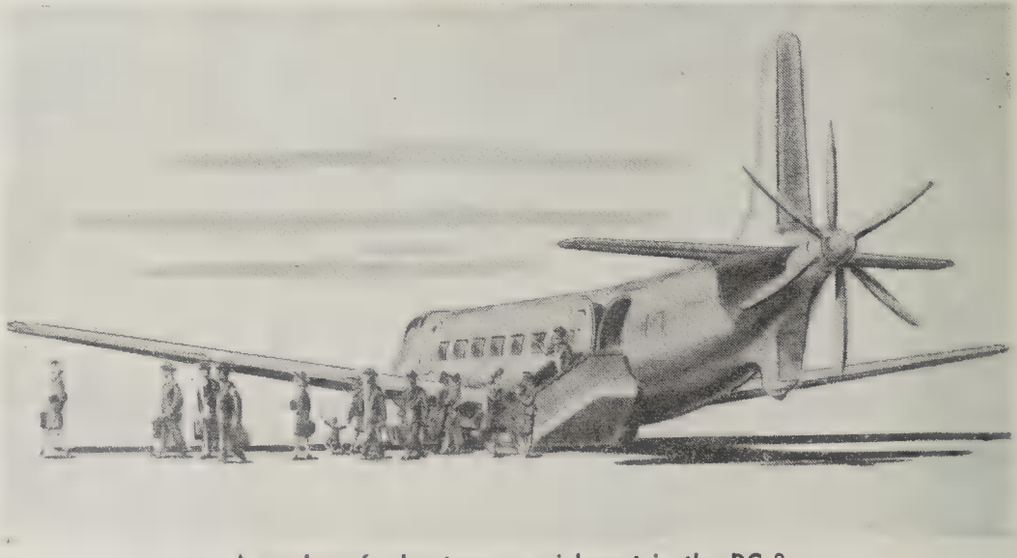
TWO-CYCLE ENGINE

Appears to Have Many Advantages

ENGINEERS have frequently said that a two-cycle aircraft engine would have decided possibilities.

Now General Motors Corporation announces a new 200-horsepower liquid cooled engine, radial in type, which seems to have solved the two-cycle difficulties. At any rate, it has very attractive specifications. The engine has four cylinders, and is provided with a supercharging blower which provides not only scavenging but also increases performance and gives reserve power for take-off and high altitude flight. Although the piston displacement is but 250 cubic inches, or about the displacement of a conventional automobile engine, the engine is rated at 200 horsepower and the weight, dry, is only 275 pounds.

This engine is perhaps the only small liquid-cooled motor ever built for aircraft use, and the diameter is only 35 inches. Fuel consumption is comparable to other engines of similar power, running about 13 gallons an hour on 91 octane gas.



A number of advantages are inherent in the DC-8

Power Brakes

Motor Vehicle Brakes, on the Average, Must Absorb Ten Times as Much Energy as the Engines Develop. Despite the High Energy Absorption of Airplane Brakes, They Are Not Yet Adaptable to Automotive Use. Current Limits of Braking Systems Must be Overcome in the Future

ALTHOUGH it appears that there is no satisfactory substitute for periodic inspection of motor-vehicle brakes, scores of research and development projects are under way to improve this phase of automotive design. Since a tremendous amount of work is afoot to improve vehicle powerplants, and extended research has been and is being concentrated upon new fuels and matching them to the engines of the future, power brake development is a natural corollary. Several engineers are exploring the possible use of the gas turbine for vehicles, and they admit that with prospective faster acceleration and higher speeds, brakes will be forced to handle unprecedented loads in dissipating the huge kinetic energies contemplated.

During recent years the establishment and exploitation of fundamental principles of braking have offset, in importance, many of the ingenious power-brake developments, in the opinion of Stephen Johnson, Jr., of Bendix-Westinghouse Automotive Air Brake Company. At a recent symposium on brakes held by the Metropolitan Section of the Society of Automotive Engineers, he declared that current loads imposed upon braking systems demand proper balancing of the brake effort, plus periodic inspection and adequate maintenance.

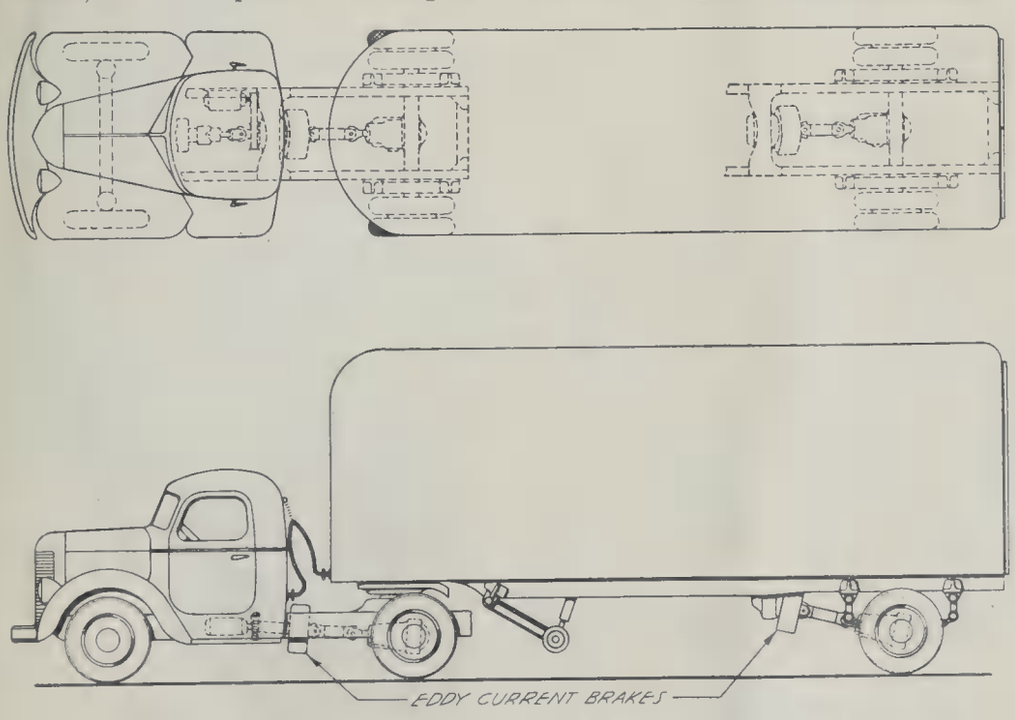
COMPLEX SYSTEM — Only comparatively recently has the brake evolved from a fairly simple mechanism to a complex system of highly specialized and effective units, without the aid of which motor transportation of passengers and freight as it is known today would be impossible. In the power brake, the composite action of all the units, from the intake of the compressor on the engine to the point of contact of the tire on the road and the last fitting or coupling on the truck and trailer train, is effective and efficient only in proportion to the fitness of each for the part it must contribute, if the final result is to be all that is desired or possible.

The analogy between the prime mover and the power brake is close. Both derive their capacity to perform useful work from the engine. The power of the engine is transmitted through the clutch, transmission, and axle—and the wheels turn. If the frictional resistance of the road to the slipping of the wheels is not exceeded, the rolling of the tires on the road moves the vehicle.

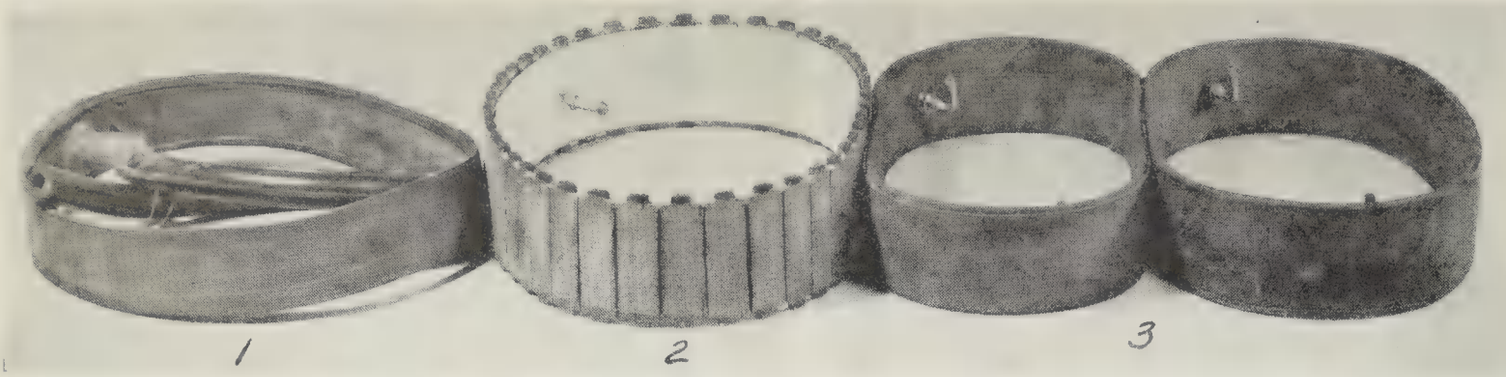
When this motion is to be reduced or stopped, the same source of energy—the engine—and the same fulcrum—the adhesion of the tires to the road—are utilized, but the impressed forces are so disposed as to resist, instead of sustain, the rotation of the wheels.

Some of the horsepower of the engine is utilized to drive the compressor or pump which supplies a convenient and manageable pressure to suitable reservoirs. This pressure is transmitted through pneumatic or hydraulic mechanisms to the brake chambers on each wheel, and the resultant force is carried to the brake drum through the cam and brake shoes, thus setting up the required resistance to the rotation of the wheels.

As greater speeds become commonplace, the loading imposed on brake systems has increased apace. Engineers used to think that practically all the effectiveness of the power brake was in the performance of the air or hydraulic devices, and that only a little of the effectiveness or efficiency came from the foundation brake gear. However, it was discovered that this ratio might well be reversed; without an efficient and properly designed foundation brake gear, the most highly developed and most efficient power brake mechanism is of little value. The brake which can transform the pressure of compressed air or brake fluid into a very great mechanical force needs a foundation brake rigging sufficiently rugged for the application of this force. If this is not provided,



How the eddy-current supplementary brake is installed on a tractor-trailer unit



Automotive engineers were recently given information on advances in aircraft brake developments. Left above is the original Linderman expander brake tube. The British Palmer tube is shown at (2) and the B. F. Goodrich tubes at (3)

every undesirable condition in braking that can be conceived may occur.

Some of the important operating developments of recent years which have aggravated the brake problem are:

1. Higher operating speeds made possible by finer highways require increased stopping ability with safety.

2. Adoption of larger section, smaller rim diameter tires increase the cooling problem and limit the diameter of brake drums.

3. State legislation which limits the overall width of the vehicle makes it difficult to find space for adequate brake drum and lining on many vehicles.

BRAKE HORSEPOWER — Naturally, the power plant or motive power equipment used to produce motion in a motor vehicle is very important, and a great deal is heard about the horsepower of the engine and the top speed of the vehicle. A great many claims are also made regarding the rapid acceleration which the increasingly powerful engine makes possible. It is just as important to slow down or stop a vehicle once it has been set in motion, but it is seldom that anyone boasts about the horsepower of the brakes.

A modern truck or bus, in starting from a dead stop, requires at least one minute—for the most powerful—up to one and one-quarter minutes for the average, to accelerate to a speed of 60 miles per hour.

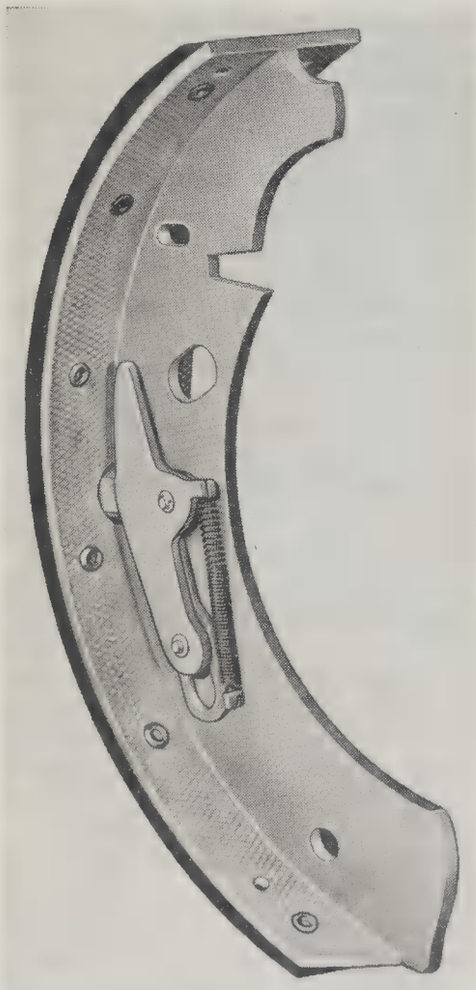
This same modern truck or bus, having brakes in good condition, can stop from a speed of 60 miles per hour in six seconds. The engine of the modern vehicle is able to develop anywhere from 100 horsepower and up; therefore, since the brakes can stop the vehicle from 60 miles per hour in one tenth the time that the motor requires to accelerate the vehicle to this speed, the brakes must be ten times as powerful as the engine. If the powerplant develops 100 horsepower in accelerating to 60 miles per hour, then the brakes must develop 1000 horsepower to stop the same vehicle with the same load in one-tenth the time.

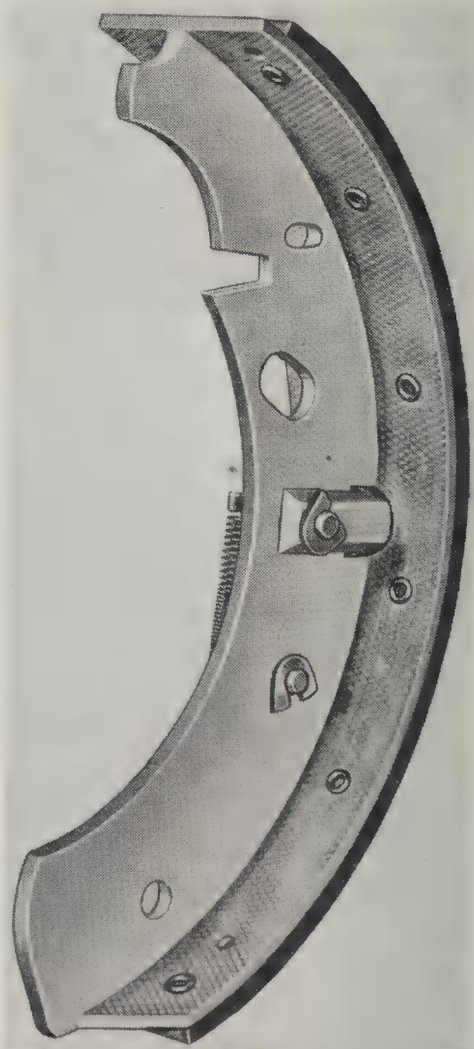
The engine has an elaborate cooling system to protect its working parts from the effects of wear. Water is carried in the cylinder block and head and circulated by pumps through a radiator mounted in the best position to take advantage of the cooling breeze. There is also a fan which helps to keep the operating temperature of the motor low. On the other hand, the brakes which do the same amount of work many times faster than the motor, are mounted on the wheels underneath the fenders. The present-day streamlining has brought the fenders down on the sides and ends, making it very difficult for cooling air to reach the brake drums and carry away excessive heat.

Brakes are mounted in positions which expose them to all the dirt and muddy water splashed from the road by the tires. This tends to lower their efficiency.

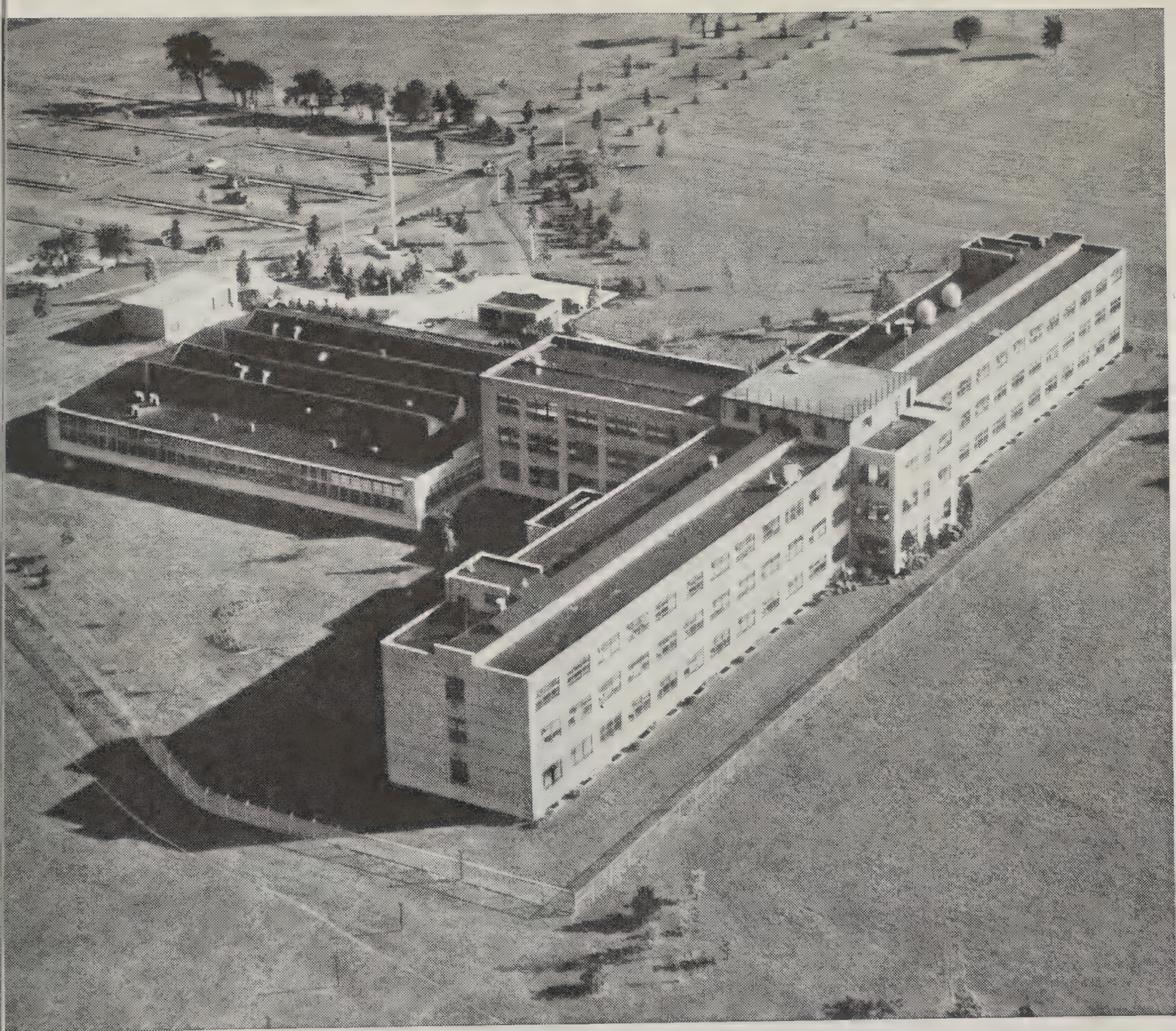
LUBRICATION PROBLEMS — The engine has a highly efficient lubrication system which insures that parts intended to slide over one another can do so with a minimum of resistance. Braking systems sometimes have the correct amount of oil and grease in the correct places, but most of them have insufficient lubrication on sliding contacts and too much oil or grease in places where they do not belong, such as on the lining surface.

These considerations are among those which have lead to an earnest





Right and left: Back and front views of Wagner's automatic brake adjuster



RCA Laboratories—Center of Radio and Electronic Research

RCA Laboratories at Princeton, N. J., are far more than one of the most modern and best-equipped laboratories ever built. It is a community of scientists, research men and technicians—each a top man in his field—each working with the other—contributing wherever and whenever his specialized knowledge will help.

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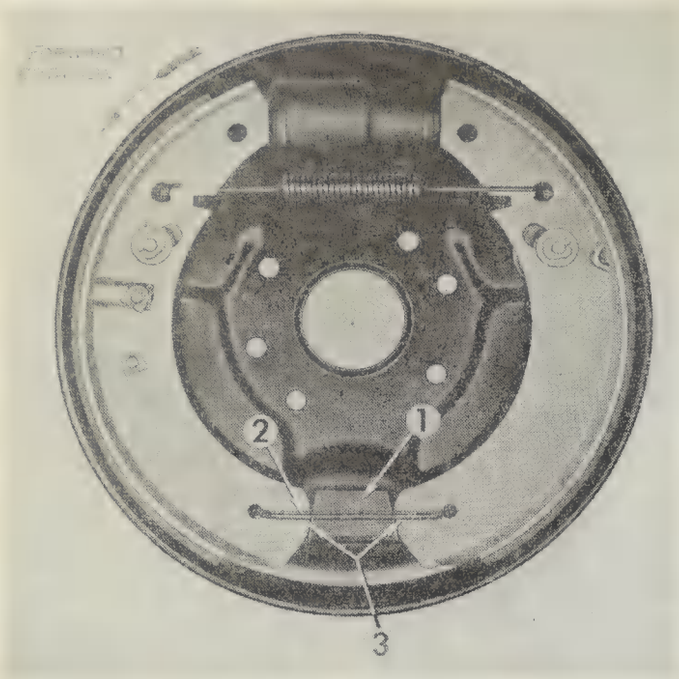
Radio Corporation of America, RCA Building, Radio City, New York 20. *Listen to The RCA Show, Sundays, 4:30 P. M., Eastern Time, over the NBC network.*

PIONEERING

Scientists and research men who work in RCA Laboratories made many vital contributions in helping to win the war through application of radio, electronic, radar and television techniques. Their skills now are devoted to peacetime applications of these sciences.

At RCA Laboratories the electron microscope, radar, all-electronic television (featuring the projection system for the home) and many other new instruments of radio, including hundreds of new electron tubes, were developed to improve and to extend the services of radio around the world.

RCA **RADIO CORPORATION of AMERICA**



A self-centering brake developed by Wagner Electric. The assembly photo shows (1) the fixed anchor and (2) the spring that holds the rounded ends of the shoe segments (3) snugly to the anchor

search for new and improved braking systems for motor vehicles. Manufacturers have scanned the field of aircraft brake engineering, in the hope that some of the tremendous effort put into this work, by large outlays of taxpayers' money, might give them a clue. In general, the expander tube and disk types of airplane brakes cannot take the long periods of braking that are imposed on motor vehicles as compared with aircraft. The concensus among brake engineers seem to be that they would cost at least three times as much as the present shoe-type automotive vehicle brake. But the translation of these aeronautical achievements is going ahead, because of the increase in braking requirements for the years to come, as compared with the current "limits" of vehicle brake systems.

A recent study made by J. George Oetzel, of Warner Electric Brake Manufacturing Company, shows that the passenger car, commercial vehicle, and city bus force their respective brakes to absorb, and to dissipate, on an average, a kinetic energy of 2455 foot pounds per square inch of active drum surfaces, whereas, in airplanes, brakes must have an energy absorption of about 12,000 foot pounds per square inch of active drum surface. He believes that brake drum and lining performance must be raised in order to chart the course of future development. In the meantime, he has been working on the development of an electrical brake system which embodies the eddy-current principle to supplement the friction type brake —particularly in operating over hilly and mountainous roads.

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DIESELS AND FUELS

Both Will Change Engineers' Concepts

NEW CONCEPTS of Diesel engines and their fuels have obsoleted the pre-war yardsticks of the cetane number scale, and the Navy has asked the engine and petroleum industries, through the Society of Automotive Engineers, to look into this question in view of supercharged Diesel power-plants and additive fuels. The cetane number indicates merely the minimum quality of fuel for starting engines and to prevent excess smoking.

Several years ago the Navy undertook to standardize Diesel engines on all of its ships—large and small—and the war caught the Navy Bureau of Ships short on supply of power-plants. One of the most pressing of war production jobs was getting enough Diesel engines built for our Navy and for the needs of our Allies. In the meantime, little development work on either fuels or Diesel engines has been done since the engineering staffs of all the engine builders have been busy on manufacturing problems of their own plants and those of their subcontractors and parts suppliers.

That a new measuring device is needed is shown by the fact that by the addition of a small amount of amyl nitrate to Diesel fuel of 44 cetane number, a Diesel engine can be made to produce the same power output per gallon as on 50 cetane fuel containing no additive.

Conversely, the newer concepts of fuel and increased supercharging of engines will require fundamental changes in the thinking of engine designers of tomorrow to obtain the best combination of engine-to-fuel relationships. While the potentialities of tomorrow's power-plants remain barely scratched, the recent emergency directed many an eye toward the future.

HANDICAPPED DRIVERS

To Be Aided by Research Now Underway

DEVELOPMENT of driving aids designed to enable disabled war veterans safely to operate cars and trucks has been undertaken by the War Engineering Board of the Society of Automotive Engineers in co-operation with Army officers, motor vehicle administrators, medical societies, and rehabilitation hospitals.

The technical committee is now testing some of the devices installed on the committee's experimental automobile. When the work is finished, the information will be made available to car, vehicle, and accessory manufacturers, garages, and others who may be interested.

LIGHT ENGINE

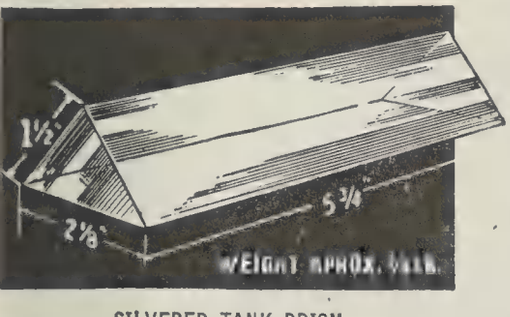
Made Largely of Aluminum, Has Auto Possibilities

COURTING the attention of automotive engineers is the Skinner gasoline engine, built largely of aluminum die-casting weldments, and soon to be manufactured in quantity by Jack and Heintz, Inc. Developed by Ralph L. Skinner over a period of 20 years, the engine is believed valuable as an auxiliary in bomber aircraft by AAF officials because of its relatively large power output due to an eight-to-one compression ratio and high speed. Weight as light as 1.75 to 2 horsepower per pound is claimed for it.

It is a double opposed or "pancake" type, and is designed so it can readily be converted from the 28 horsepower two-cylinder unit to multiples thereof. Therefore, its sponsors believe, it will fit readily into the automobile's future if it can be produced at a reasonable cost per horsepower.

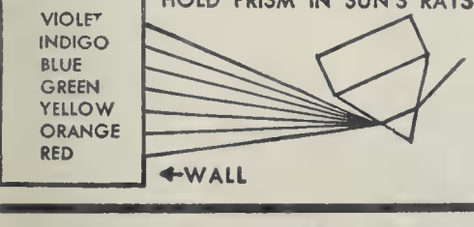
Detroit reports indicate that Henry J. Kaiser and Joseph W. Frazer are interested in the Skinner-Jack and Heintz proposition. An immediate consideration, in respect to price and availability, is the large surplus of aluminum alloys resulting from war order cutbacks on the one hand, and the continued shortage of gray iron castings—despite these cutbacks—on the other. Old-line automobile companies are currently having trouble in getting sufficient gray iron castings for their projected manufacturing schedules.

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. . . The most sensational bargain we have ever been able to offer.



TANK PRISMS

In order that the tank driver shall not get shot in the face, 2 of these Silvered Prisms are used to make a Periscope. We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree Prisms of huge size—5¾" long, 2⅛" wide, finely ground and polished. Used to build a Periscope . . . excellent also for experiments, classroom demonstrations. Some of our ingenious customers have used these prisms to make camera stereo attachment, range finder, etc. Prism easily converted into desk name plate by affixing gold letters. 100 gold letters supplied at only 10c. (Order Stock #3008-S.) Normally these Prisms would retail from $24 to $30 each.

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523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼". Each	.25
624-S	Neutral Ray Filter size 4¾" x 2½"	.25
3022-S	Round Wedge 65 mm. Diam. Each	5.00
22-S	Inclinometer—Aircraft type. Each	.25
704-S	Lens Cleaning Tissue, one ream (480 sheets), size 7½" x 11"	1.50
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(Minimum Order on Above—1.00)

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3042-S	Right Angle	41 mms.	40 mms.	1.00
3045-S	Right Angle	70 mms.	168 mms.	8.00
3001-S	Lens Surface	20 mms.	14 mms.	2.00
3009-S	Porro	52 mms.	25 mms.	1.00
3016-S	Pentagon	45 mms.	22 mms.	.75
3029-S	Dove	16 mms.	65 mms.	1.25
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More Oil From Wells

A Method of Horizontal Drilling, Using a Turbine-Operated Bit, Holds Promise of Opening New Oil Horizons. Applied to Old and Seemingly Exhausted Wells, this New Procedure May Make Available Millions of Barrels of Oil that Otherwise Would Remain in the Earth

WHILE guesses are constantly being made as to the probable extent of the petroleum resources of the world and the length of time it will take to exhaust them, petroleum engineers have steadily improved production from older oil fields by drilling deeper wells and utilizing improved means of extracting the crude oil known to lie under the surface.

One of the latest methods of more efficiently tapping the known underground sources of crude oil is that invented and put to use by John A. Zublin, a Los Angeles manufacturer of drilling equipment. His method is to drill several holes in a horizontal direction, stemming many feet from the original vertical bore of an oil well. Thus a greater area of oil producing formation is tapped by the original bore. Up until now the only successful method of mechanically increasing drainage into a well has been by "gun-perforating"—shooting of bullets through the sides of the bore into the formation. But bullet holes are small and can penetrate only a few inches into the oil sands.

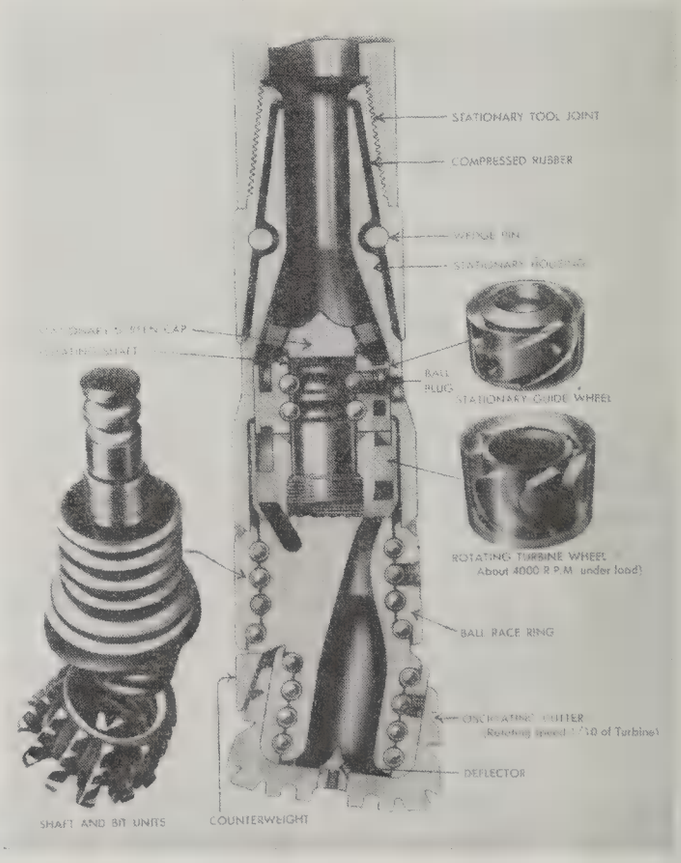


Left: Three units required in drilling a horizontal hole. A mandrel; a curved, flexible drill pipe; and a pressure operated turbine bit

Assuming that an oil well extends down into a producing oil sand for a distance of say 60 feet, it would normally drain only 60 feet vertically. By drilling a series of eight horizontal holes, each 100 feet in length, an additional 800 feet of drainage can be added, or in the ratio of 13 to 1.

Of course, the actual area drained by any well drilled through or into a producing sand is problematical. This applies whether the hole is vertical or penetrates the sand at an angle, as when the well is drilled by directional control to reach a predetermined point some distance from the surface location or when the bore "wanders" from the vertical. The flow of oil to the bore is governed by many natural factors such as permeability and porosity of the sand and the cementation of the grains, and by adverse factors tending to retard the flow of fluid into the bore, such as infiltration of water from drilling mud, plastered faces due to use of improper mud, and sloughed sand.

As a well produces, the flow of oil to the bore increases and movement of fluid from the outer circumference of the assumed drainage area becomes less. Actually, the true drainage area probably shrinks as the well produces and much more



Right: Detailed drawing showing the construction of the Zublin turbine bit used in drilling horizontal holes from a vertical bore



A Timely Message to Americans

from
The Secretary of the Treasury

America has much to be thankful for.

Abroad we have overcome enemies whose strength not long ago sent a shudder of fear throughout the world.

At home we have checked an enemy that would have impaired our economy and our American way of life. That enemy was inflation—runaway prices.

The credit for this achievement, like the credit for military victory, belongs to the people.

You—the individual American citizen—have kept our economy strong in the face of the greatest inflationary threat this nation ever faced.

You did it by simple, everyday acts of good citizenship.

You put, on the average, nearly one-fourth of your income into War Bonds and other savings. The 85,000,000 owners of War Bonds not only helped pay the costs of war, but also contributed greatly to a stable, prosperous postwar nation.

You, the individual American citizen, also helped by cooperation with rationing, price and wage controls, by exercising restraint in your buying and by accepting high wartime taxes.

All those things relieved the pressure on prices.

THE TASK AHEAD

We now set our faces toward this future: a prosperous, stable postwar America—an America with jobs and an opportunity for all.

To achieve this we must steer a firm course between an inflationary price rise such as followed World War I and a deflation that might mean prolonged unemployment. Prices rose more sharply after the last war than they did during the conflict and paved the way for the depression that followed—a depression which meant unemployment, business failures and farm foreclosures for many.

Today *you* can help steer our course toward a prosperous America:

—by buying all the Victory Bonds you can afford *and by holding on to the War Bonds you now have*

—by cooperating with such price, rationing and other controls as may be necessary for a while longer

—by continuing to exercise patience and good sense with high faith in our future.

The challenge to America of switching from war to peace with a minimum of clashing gears is a big one.

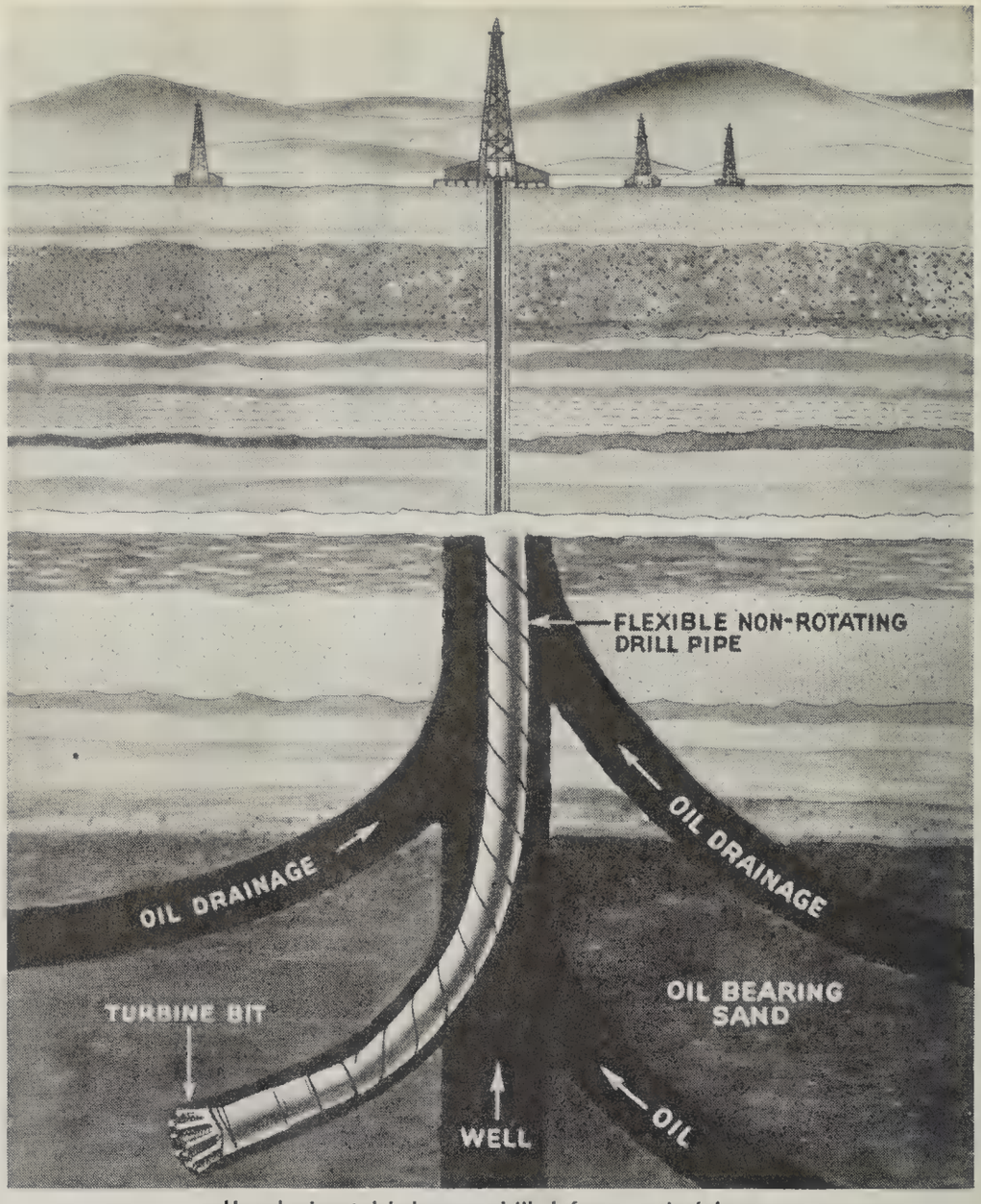
But it is a small one compared to the tasks this nation has accomplished since Sunday, December 7, 1941.

Fred M. Vinson
Secretary of the Treasury

A Government message prepared by the War Advertising Council and contributed by this magazine in cooperation with the Magazine Publishers of America.

oil at a distance from the well is left in the sand than is left in the area immediately surrounding the bore. Moreover, additional retarding factors enter the picture, both in the sand itself and at the face of the hole. Among these are fine sand clogging the pores of the oil-producing sand, sloughing sand in the hole or around the liner, and deposition of colloidal and residual matter from the oil itself.

The drilling of horizontal tributary holes from the vertical bore provides a means of increasing the movement of oil from the entire drainage area of a well. Each of these horizontal drain holes establishes an individual drainage area within the assumed range of the well and provides a passage for the flow of oil from its drainage area to the original vertical hole. Horizontal drilling is therefore advantageous when drilling new wells, in old wells for stimulation of production, for production from wells that have fallen below the economic limit, and in wells being produced by secondary methods such as pumping.



How horizontal holes are drilled from vertical bore

HOW IT IS DONE—The equipment for horizontal drilling consists essentially of a turbine bit and flexible drill pipe. The bit is rotated by the drilling fluid—water and mud—which is circulated by the mud pumps, the fluid being maintained at a suitable viscosity for operation of the bit. The drill string is not rotated during the normal course of drilling the horizontal hole.

One or more horizontal holes may be drilled from the vertical bore, the number being determined by the well conditions and the experience of the operator. The holes take off from the well in a vertical arc and may be located at desired vertical distances above each other. The holes can be started at any point in an open hole or through windows cut in the liner or casing. The direction of the horizontal holes may be predetermined and the holes started off in any desired direction by properly orienting the drill string in the well.

The lower part of the drill string used for drilling a horizontal hole consists of the number of joints of flexible drill pipe necessary to carry the hole for the distance from the vertical bore to the point in the sand to which the horizontal hole is to extend. The bottom flexible joint to which the bit is attached is made from a curved section of drill pipes. This causes the hole to start off in an arc as the bit begins cutting. The other flexible joints are straight and follow the curved joint along the arc which it establishes. The upper portion of the drill string is made up of conventional drill pipe.

The flexible joints at the lower end of the drill string are made from 4½ inch flush-joint drill pipe. A spiral slot is cut through the wall of each joint of pipe throughout its entire length and the joint is lined with a high pressure rubber hose, made fluid tight at each end to prevent leakage of the power-circulating fluid. The spiral slot provides adequate flexibility for the pipe to change from a vertical to a horizontal direction as it passes from the vertical well bore into a horizontal hole.

The curved flexible joint used at the end of the string, and to which the turbine bit is attached, is made by cutting a spiral slot in a joint of drill pipe that has been bent to a definite radius and heat treated to maintain its curved form. A 25-foot radius joint will allow the hole to continue in approximately a horizontal direction after the vertical arc from the bore has been drilled since gravity causes the curved joint to straighten out as the bit continues to bore the hole. Should a slightly upward inclination be desired for production reasons, a curved joint of smaller radius can be used.

Before the curved section of pipe is run into a well, a mandrel is inserted as a core. Thus the curved joint is held in a straight position until it has reached the point of operation. Then the mandrel is withdrawn and the curved pipe is allowed to assume its curved form within the limits of the hole in which it is confined.

THE TURBINE BIT—The rotary turbine bit attains a high rotational speed by means of power derived from the energy of the fluid pumped down the drill string. The cutting action of the bit depends in part upon the tendency of the cutter teeth to lift and drop the bit. A highly efficient bearing mechanism is therefore provided to carry the axial loads imposed by the tendency of the bit to rise and fall.

The entire bit—including housing, turbine, and cutting member—is made as short as possible to provide for starting the curved hole with

which the horizontal hole takes off from the vertical. The overall length is only 20 inches. The driving fluid is discharged as close to the cutting teeth as possible in order to remove cuttings from the bottom and to keep the bit and well bore clean.

DRILLING PROCEDURE—In operation, the turbine bit is attached to the bottom of the curved joint of flexible pipe which is flexed to a straight position and kept straight by the mandrel. Above this are the required number of straight flexible joints to reach from the vertical bore to the point in the sand where the horizontal hole is to end. These make up the lower portion of the drill string which consists otherwise of conventional drill pipe. When the bit reaches the depth at which the horizontal hole is to take off from the vertical, the mandrel is removed and the lower joint allowed to return to its curved form to the extent the hole will permit. The drill string is then hooked up to the pumps which deliver the mud-water fluid at a pressure of from 225 to 600 pounds per square inch, or sufficient to operate the turbine drill bit at 4000 revolutions per minute.

When the pumps are started, the bit, being forced by the curvature of the flexible pipe against the side of the vertical hole, will begin to dig into the wall of the bore and start a new hole at the point where it is positioned.

⊕ ⊕ ⊕

WEED KILLING

Petroleum Spray Leaves no Residual Taste in Vegtables

OVERCOMING the chief disadvantages of weed-killing fluids with which farmers have experimented for many years, a new petroleum-derived weed-killing spray has been developed which is reported to impart no taste to the vegetables, whereas sprays of kerosine and other petroleum fractions have often ruined entire crops because of their residual taste.

Known as Sovasol 5, the new weed killer has completed a full season of field tests, according to Socony-Vacuum Oil Company, Inc., who developed it. Recommended *only* for use in carrot, parsnip and parsley fields, it has been successful in destroying weeds at a cost of less than $12 an acre as compared to $60 an acre in hand-pulling methods.

The weed-killer is a thin, water-white liquid that evaporates, leaving no apparent residue. Within a few hours after its use, the weeds begin to wilt and in a few days appear as if they had been killed by a sudden frost.

About 80 gallons of the liquid are required for each acre, and almost any kind of spraying apparatus may be used, elaborate equipment being unnecessary. Experiments have shown that it is important to treat areas when the carrots have reached the two or four leaf stage. A second treatment may be applied the following week, if desired, but it is rarely necessary. Slightly better results have been noted when spraying is conducted on damp days but this is said to be relatively unimportant.

Destruction of weeds is important in carrot, parsnip, and parsley production since these vegetables are so slow to germinate that weeds may gain headway before they can be pulled out without injuring the tender plants. In the great carrot growing areas of the West such as the Salina, San Joaquin, and Imperial valleys of California and the Yuma and Salt River valleys of Arizona, where cost of irrigation is also an important agricultural item, destruction of weeds is most imperative because of their competition with the crop for water.



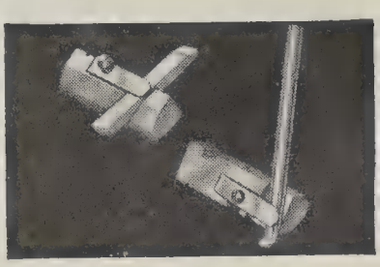
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Acro Master Grinding Gauge



Remember this wrapper

Z-90

'Mightiest Nothing'

Helium, Best Known for its Use in Airships, is Being Developed for Many Other Purposes; Today it Finds Important Applications in Deep-Sea Diving, Medicine, and Welding as Well. What of the Future?

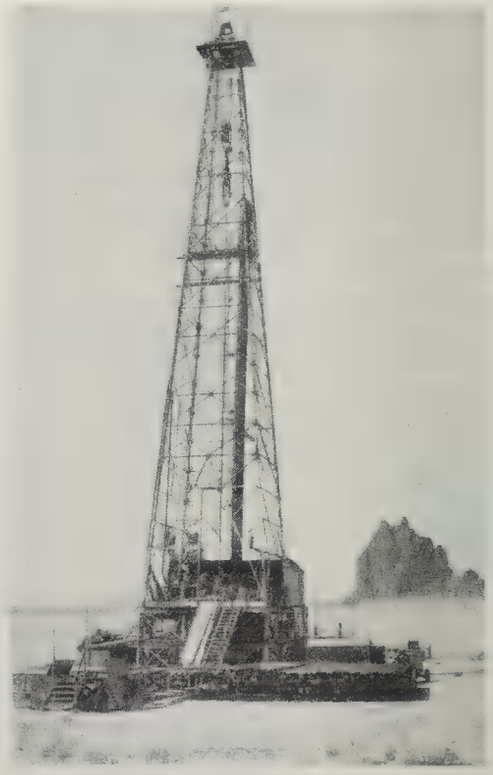
By LEWIS NORDYKE

MENTION of helium brings to most a vague notion of something with which to inflate balloons and blimps. But this rare, inert, gaseous element, which is an exclusive product of the United States because it has been found in important quantity only in the natural gas of some of our mid-continent fields, has proved to be a precious possession with increasing numbers of vital war, industrial, and medical uses—from welding parts for B-29 bombers to starting breath in newborn babies.

Scientists refer to the gas as our "mightiest nothing." This is because helium is tasteless, odorless, colorless, non-flammable, non-explosive, and non-poisonous; it has only one seventh the weight of air and steals into places where few other things can go, but it is so aloof it won't combine with other elements. Helium, often found with natural gas, cannot be made from anything else. It is an individualistic element.

Its "non-everything" properties are what make it great; it is indestructible and can be used under any conditions because it leaves no after-effect in the human body or in the snorting hot nozzle of a welding torch.

The United States has had this prize possession to itself since 1918, when the government started separating helium from natural gas for use in inflating airships and balloons. It was considered so important for this purpose that the Bureau of Mines of the Department of the Interior took over control of production, and helium became a government monopoly. Not until 1937, when Congress passed a law permitting the sale of surplus helium to anyone needing it, was the gas available to private interests and the general public, even for adequate research. War-time needs were so great that production was stepped up almost unbelievably; now, for the first time, there is plenty of helium for present and potential uses, at reasonable cost. The importance of the fact that the United States had helium and knew how to use it as a war material can't be exaggerated.



A gas well in the Rattlesnake field



All photographs from Bureau of Mines, Department of the Interior

Multiple-cylinder tank car for transporting helium

GERMANY WANTED IT — Helium is the one thing German scientists didn't have. Germany begged for it in 1937 after the *Hindenburg* exploded and burned over Lakehurst, New Jersey. The plea was on the grounds that the non-explosive gas was needed for the furtherance of commercial lighter-than-air craft. Secretary of Interior Harold L. Ickes decided that Germany might want the gas for military experimentation or use; so he refused to approve exporting the helium.

Not long after the German submarine packs started blasting our coast-wise and sea-going shipping, the Navy was able to send out fleets of helium-filled, snub-nosed blimps to search out and destroy the subs. Admiral Charles E. Rosendahl reported that not a ship was lost from a convoy protected by the sausage-shaped gas bags, which were also used for rescue and observation at sea. Helium lifts observation balloons for the United States Weather

Bureau and has proved to be of tremendous value to military weather men. With the vast expansion of aviation, weather stations had to be moved to the air fields. Sounding balloons carry instruments high in the sky for recording data from which essential long-range forecasts are made. Use of explosive gas is dangerous around airports; helium is as safe as a child's breath.

METAL WORKING — The use of helium in war industry has been of extreme importance, as it now is in peace-time. It makes possible the welding of light metals so essential to airplanes. Magnesium, which is only two thirds as heavy as aluminum, and of amazing strength, is ideal for aircraft, but it can't be welded satisfactorily in the ordinary manner. Fire from the torch might ignite it and it would disintegrate like a Fourth of July sparkler. With a helium-carrying tube in its nose, the welding torch snorts out a thin shield of the gas that won't burn. This constant shield protects the magnesium from the air and makes possible an effective, smooth weld.

Helium has proved as valuable in the welding of stainless steel, and it promises revolutionary improvement in the welding of many metals. Many precision tools and metal parts are shaped while the steel is soft and then given the right temper, or hardness, through heat treatment. Even the most carefully worked metal may develop objectionable properties through absorption of oxygen (known as oxidation) if, after heat treatment, it cools in the natural atmosphere. When cooled in an inert atmosphere of helium, oxidation is impossible.

UNDER WATER—A synthetic atmosphere of helium and oxygen has revolutionized deep-sea diving. Until helium-oxygen mixtures were used, the maximum depth for a diver was about 300 feet, and he could stay there only a few minutes; now—as a result of co-operative research by the Bureau of Mines and the Navy Department—he can stay at that depth for six hours and can work at a depth of almost 600 feet for shorter periods. When breathing ordinary air while under high pressure at great depths, the diver may suffer temporary lapse of mental faculties, but in air containing a percentage of helium his mind remains clear. The gas also reduces one of the biggest dangers to the diver on his return to normal atmospheric pressure: caisson disease, or the bends. This is caused by bubbles of dissolved nitrogen popping out of the body fluids, as pressure is reduced, and collecting in joints and blood vessels. In the new mixture, helium replaces nitrogen and is less apt to cause bubbles because it is one half as soluble as nitrogen and diffuses out of the blood twice as fast.

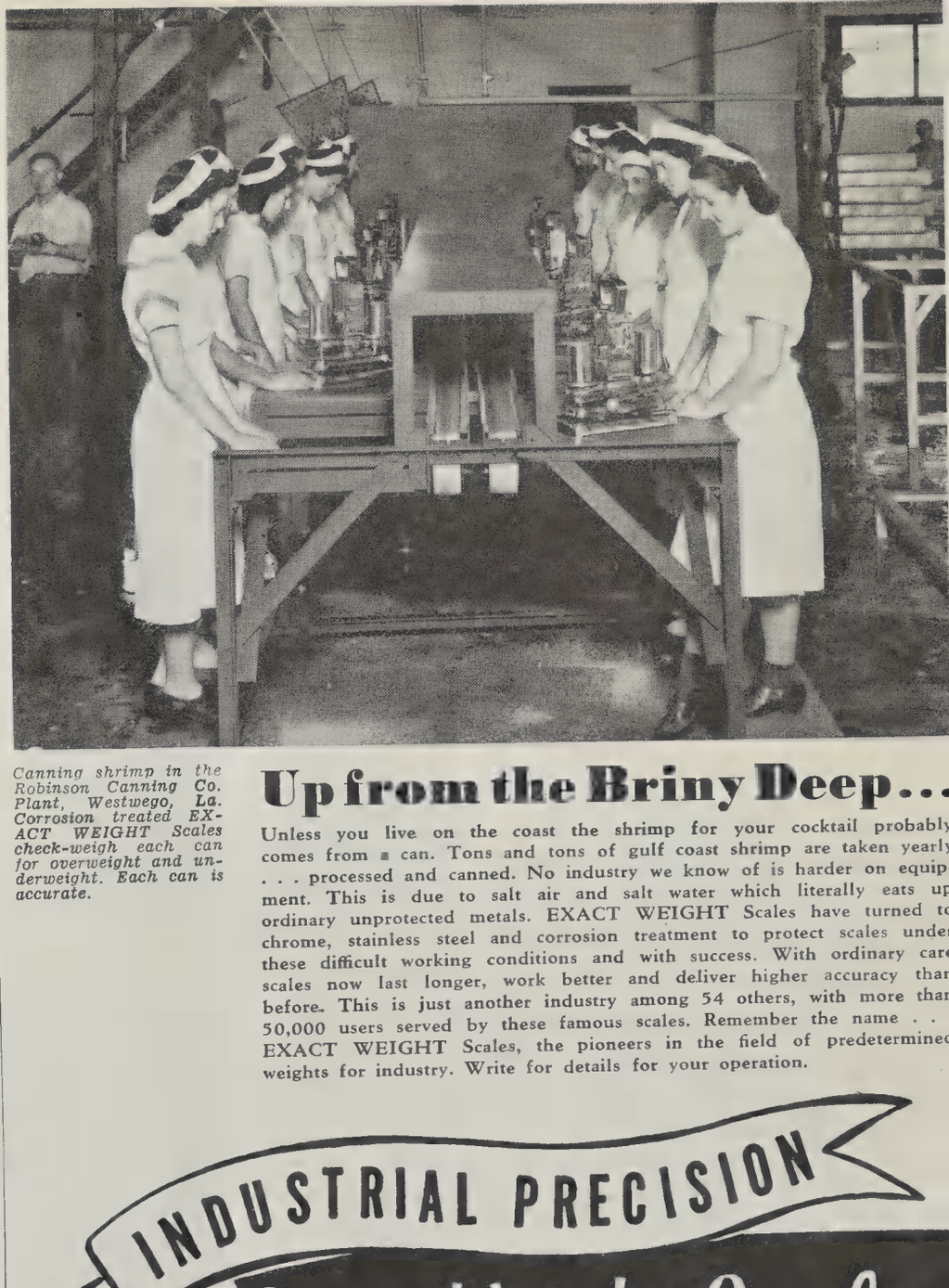
Another new use for the gas is for inflation of airplane tires. In a big liner such as the Lockheed Constellation, for example, use of the much lighter helium instead of air in the tires reduces the weight of the plane by 100 pounds.

IN MEDICINE—One of helium's big future roles, that may well affect everyone, lies in medicine. Nearly all first-class hospitals are already equipped with tanks of the gas.

Dr. Alvan L. Barach of Columbia University reports that helium has saved the lives of people with very severe asthma. A victim of asthma can take a few whiffs of an oxygen-helium mixture and get almost immediate relief. The helium is so light it is easier to breathe; it penetrates clogged, swollen passages and carries with it the needed oxygen.

The gas is likewise used for treating other respiratory ailments, including tuberculosis and pneumonia and in aiding infants whose lungs fail to expand normally at birth.

People have died on operating



Canning shrimp in the Robinson Canning Co. Plant, Westwego, La. Corrosion treated EXACT WEIGHT Scales check-weigh each can for overweight and underweight. Each can is accurate.

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Unless you live on the coast the shrimp for your cocktail probably comes from a can. Tons and tons of gulf coast shrimp are taken yearly . . . processed and canned. No industry we know of is harder on equipment. This is due to salt air and salt water which literally eats up ordinary unprotected metals. EXACT WEIGHT Scales have turned to chrome, stainless steel and corrosion treatment to protect scales under these difficult working conditions and with success. With ordinary care scales now last longer, work better and deliver higher accuracy than before. This is just another industry among 54 others, with more than 50,000 users served by these famous scales. Remember the name . . . EXACT WEIGHT Scales, the pioneers in the field of predetermined weights for industry. Write for details for your operation.

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tables because of the explosion of an anesthetic in their lungs. A mixture, which can't explode, made by adding helium to the anesthetics, eliminates the danger. Moreover, the light helium mixture goes into every nook and crevice in the lungs and when it is exhaled it brings out a portion of the anesthetic that otherwise might linger in pockets and cause serious after-effects

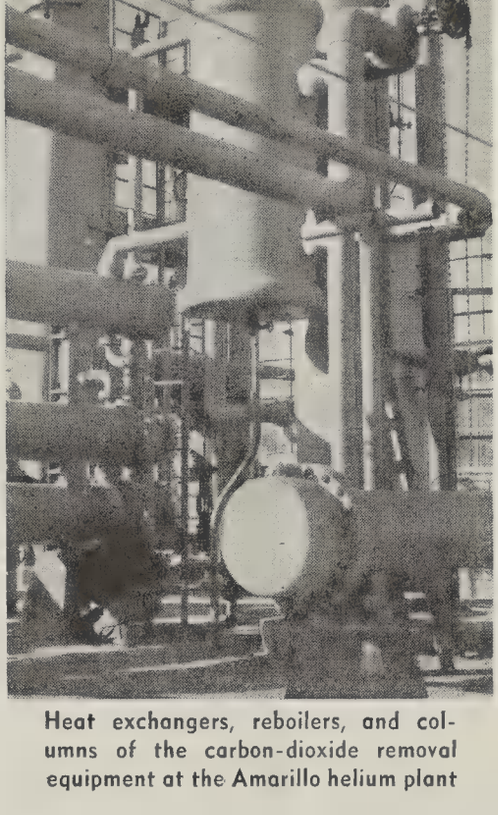
The gas also has promise in the treatment of sinus infection. Because of its penetrating properties, it can go into passages which are stopped so tightly that air can't enter.

PRODUCTION — The Bureau of Mines owns a lease on rich helium gas acreage in the Rattlesnake fields near Shiprock, New Mexico; two reserves totaling 16,000 acres in Utah; and the 50,000-acre Cliffside field near Amarillo in Texas. Before the war, the separation plant at Amarillo was the only one in the world. When the nation started arming, C. W. Seibel, supervising engineer at the plant, was assigned the job of increasing production. Refineries were built at Otis, Kansas; at Exell, near Amarillo; and at Shiprock. The gas from the Rattlesnake field is richer than any other from which the Bureau of Mines has produced helium. It has a 7 percent helium content, while the average of other fields is less than 2 percent.

SALVAGE—By October 1945, production was so great that it became possible to close down all the plants except the one at Exell. This plant uses gas from commercial natural gas fields; consequently, no helium whatsoever is being taken today from the government's rich reserve. Instead, helium for future use is being pumped from the Exell plant and stored in the government owned Cliffside field.

For years, natural gas with 1 percent helium content had been going to commercial market, and the helium went along and was wasted. The Exell plant was built to snare that wasted helium. The natural gas now goes through the separation plant and the helium is removed; then the natural gas, slightly improved as fuel because of removal of the non-burning element, goes back into the pipe lines for use in homes and factories. This was also the case at Otis. Some 17 billion cubic feet of gas had been removed from the Cliffside field, so there is plenty of room for the storage. The important thing about this arrangement is the fact that helium that was formerly going to waste is now meeting the present demand for the gas and at the same time increasing every day the supply in the government's reserve.

Refining of helium is a fairly simple process, if the almost automatic separating equipment and refrigeration system is taken for granted. The natural gas containing



Heat exchangers, reboilers, and columns of the carbon-dioxide removal equipment at the Amarillo helium plant

the helium is piped from the wells into the plant under pressure of 600 pounds to the square inch. It is first washed in a chemical solution to remove carbon dioxide. Then the gas goes into the pipes of a refrigeration system and is cooled to 300 degrees below zero, Fahrenheit. This liquefies everything except the helium, which is removed in gaseous form from the liquid and goes out of the plant into steel bottles or specially-built tank cars, ready for shipment. The remaining natural gas is sold to a gas company.

DISCOVERY—Seibel has done more than any other person to develop helium from a laboratory play-thing to a plentiful product of vital uses. When he started toying with it as a student in the University of Kansas 30 years ago, helium was a chemical curiosity. It was first discovered in 1868 by J. Norman Lockyer, a British scientist, while he was studying light from the sun with a spectroscope. He found a spectrum line never before recorded, indicating the presence of a hitherto unknown element in the flaming vapors of the sun. He named the new found element "helium," from the Greek "Helios," meaning sun.

A small amount of the gas was found on earth in a radioactive mineral in 1895 by Sir William Ramsay of England; in 1905, Dr. H. P. Cady, chemistry professor at the University of Kansas, analyzed gas from a near-by oil well and found that it contained 1.87 percent helium. Seibel, a student of Dr. Cady, wrote the thesis for his master's degree on a study of helium, and in April, 1917, the month the United States entered World War I, read it at a meeting of the American Chemical Society in Kansas City. At the time, there was about one cubic foot of helium in the United States. It had been purified in a laboratory and was sold at the rate of $2500 a cubic foot. Britain was pleading with the United States to try to develop a non-explosive filler for airships.

Dr. R. B. Moore, a Bureau of Mines chemist, and others obtained funds from the War and Navy Departments for helium research. A nation-wide hunt for helium-bearing natural gas started; samples of gas from every known field were sent to Seibel for analysis. The most promising was one near Fort Worth, Texas. Machinery used in liquefying air was modified so that it separated helium from natural gas. When the war ended, there were 147,000 cubic feet of helium on the New Orleans docks ready for shipment to England. It had cost less than 50 cents per cubic foot. Since then the production cost has been cut to one cent per cubic foot, or less.

EXPANSION AHEAD—Seibel thinks that great expansion in the uses of helium lies in the days ahead. Since the end of World War II, he has been actively concentrating on the development of new uses for helium. He has offered industrialists the cooperation of the Bureau of Mines in experimentation and in providing the gas in adequate quantities. His ultimate objective is to produce so much helium at such low cost that industry and medicine will find more and more jobs for it to do.

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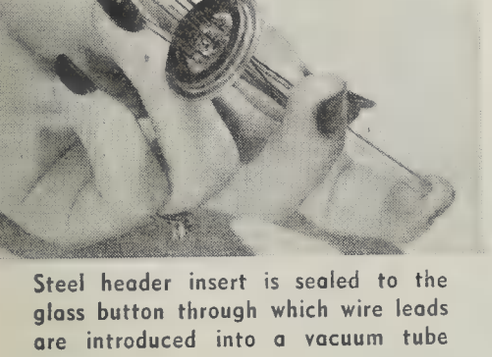
STEEL-TO-GLASS

Seal Makes Electron Tubes Airtight

FUSING steel and glass in a permanent airtight seal for metal electron tubes is now being done by a new method developed by Radio Corporation of America. The method provides a more foolproof process, in addition to permitting the use of a staple metal for the glass-to-glass seal in place of special alloys which are more costly and sometimes scarce.

The new procedure depends upon ne control of processing so as to ecure good "wetting" of steel by lass. At the same time, it incorpoates a mechanical design which rovides compression strains at the lass-metal boundary, and thus ompensates for differences in exansion of the two materials.

The surfaces sealed by the new nethod are the outer edge of a flat, ound, glass button and the inside f a metal band known as the header nsert. The glass button serves to nsulate the wire leads which conect internal elements of the tube with the pins on the base. The eader insert is used to join the utton to the header, a ring of teel which, with the button, forms



Steel header insert is sealed to the glass button through which wire leads are introduced into a vacuum tube

the "floor" of the tube, and is welded to the open end of the metal envelope to support the internal structure and complete the enclosure.

The principle which now permits the use of steel for the header insert involves the fact that glass is a solvent for oxides. By applying intense heat from fine jets of gas flame to the outside of the oxidized steel band, after the glass has been softened and pressed into a button inside the band, it is possible to cause any excess oxides to dissolve into the glass. Before this principle was applied, too much oxidation was as serious an obstacle as too little, the latter preventing adhesion, while the former left a porous interface between the metal and the glass.

CONCRETE CURING

Tests Show Comparative Ultimate Strengths

COMPARATIVE strength and wear tests of Portland cement concrete are reported in an article prepared by H. C. Volmer for publication in the *Proceedings of the Highway Research Board.* The concrete specimens were stored at 70 degrees, Fahrenheit, and 50- to 60-percent relative humidity. Six methods of curing—burlap, integral, and surface calcium chloride, and three samples of sprayed surface membranes—were used. Damp burlap for 18 hours with calcium chloride used either integrally or spread on the surface upon removal of the burlap, gave 28-day strengths of the same order as the three-day wet-burlap method. The strengths obtained with the three sprayed membranes were lower. Compared to the specimens cured with burlap for three days, the specimens cured with surface or integral calcium chloride had higher wear resistance, and specimens cured with the three membranes had lower wear resistance.

FABRIC FIRES

Depend Largely Upon Construction

FLAMMABILITY of textile fabrics is not necessarily due to the kind of fiber from which the fabric is made, but depends more upon the construction of the fabric and particularly on whether the fibers used are brushed out or are in the form of a long pile, according to Dr. Frederic Bonnet of the American Viscose Corporation in a discussion of current proposed legislation designed to curb the sale of flammable fabrics.

When fibers such as cotton, rayon, linen, or ramie are twisted together into a thread and then woven into a compact cloth with few or no fine fibers protruding from the surface, they are not readily flammable, or subject to rapid combustion, Dr. Bonnet pointed out. When, however, such fibers are in a finely divided state and thus permit the ready access of air, they are rendered quite flammable.

Flammability may also be caused by the use of a flammable finish applied to glaze the surface and so make a fabric more easily cleanable, Dr. Bonnet said.

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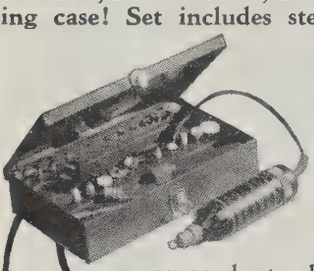
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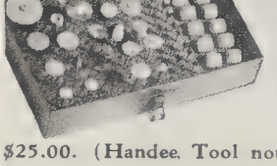
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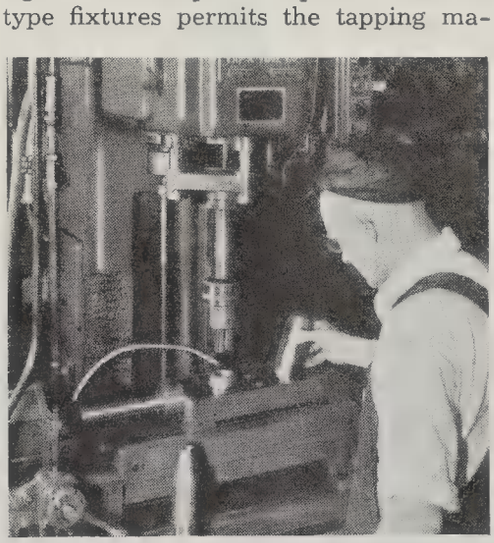
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New Products and Processes

AIR-OPERATED FIXTURES

Make Fast Precision Tapping Possible

USE OF simple air-operated combination clamping and positioning fixtures on medium duty lead-screw tapping machines has made possible continuous high production precision tapping of even blind holes. The loading speed and tapping accuracy resulting from the design of the simple two-position shuttle type fixtures permits the tapping machines to operate on automatic-repeat cycles, relieving the operators of the necessity of starting, stopping, and reversing the machines.



Pneumatic positioning and clamping fixture in place on tapping machine

The equipment—designed and built by Detroit Tap and Tool Company—comprises hand controlled air-cylinder and piston operated shuttling fixtures, with two-piece work holders bearing on convergent vertical ways of clamping and horizontal locating, and vertical positioning pins for accurate control of tapping depth. The taps for blind hole tapping are standard four fluted "Detroit" taps ground with a short chamfer, driven at approximately 70 feet per minute and guided by lead screws that are not subjected to the cutting torque.

ELASTIC SILICONE

Unaffected by Intense Heat

BUILT upon a tough, heat-stable skeleton of silicon and oxygen atoms, Silastic, a family of elastic silicone products, is the latest group of high polymeric organo-silicon oxide polymers to develop from laboratory research into commercial production. These new rubbery silicones provide another class of silicone products which fill the need for rubbery materials combining heat resistance with elasticity or compressibility.

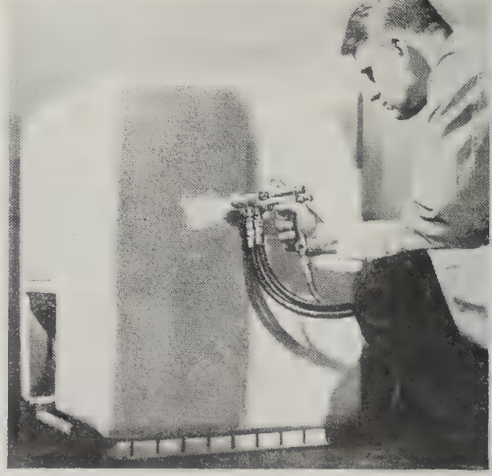
Silastic, developed by the Dow Corning Corporation, now provides a group of engineering materials which remain elastic and compressible at temperatures of 300 degrees, Fahrenheit, for long periods and can be used at temperatures up to 480 degrees, Fahrenheit, for certain applications. Silastic covers a series of heat-stable, oxidation-resistant elastic silicone products characterized by their good dielectric properties and chemical resistance. Silastic is furnished compounded ready for molding, extruding, or coating in several stocks covering a range of physical properties and hardnesses. This new product opens new lines of engineering thought wherever the problem can be solved by a material which retains its compressibility at elevated temperatures. It also retains flexibility at temperatures far below zero, together with good electrical properties, arc-resistance, chemical inertness, and water-proof qualities.

TWO-COLOR FINISHES

Applied in One Coat By New Spray Gun

TWO-COAT spatter finishes and simulated hammered finishes which give the effect of iridescent metal are now possible in one spraying operation with a newly-developed spray gun which sprays two colors simultaneously through one nozzle.

Ideally suited for decorating automobile dashboards, radio cabinets, sewing machines, lighting fixtures, vacuum cleaners, and other metal products where a finish combining beauty and durability is desired, it provides a one-operation finish that is more durable, faster, and cheaper to apply than conventional hammer and spatter finishes requiring two or three operations. The



It looks like an ordinary spray gun, but it applies a new two-color finish

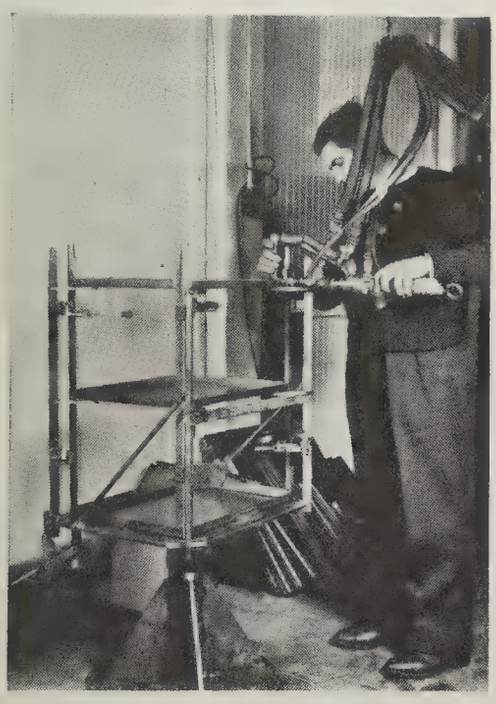
smooth finish, moreover, has no dust-collecting cracks, wrinkles, or fissures typical of crackle and wrinkle finishes.

Known as the Dimenso gun, a development of the Sherwin-Williams Company, it differs but slightly from ordinary spray guns in appearance or operation. It has the normal spray fan control valve and fluid control valve, trigger assembly, head, fluid tip, and needle. However, it has an additional fluid inlet near the head of the gun to accommodate the second color paint.

PRODUCTION WELDING

Speeds Market Tryout For New Product

SPOT welding with automatic or semi-automatic equipment can be employed to get certain types of products on the market economically and with much greater speed than has heretofore been possible. With the aid of assembly spot welding, a cabinet company was able



Assembly spot-welding of tables carried out with minimum of investment

to produce a trial lot of all-steel utility tables without major investment in production equipment on the part of the manufacturer. Portable gun spot welding—carried out in the job welding department of Progressive Welder Company—was the fabricating method used.

A standard C-type Progressive portable resistance welding gun was used to make the spot welds. Only a single clamping type rotary work-holding fixture was necessary to complete the assembly of the tables. A production speed of 16 tables per hour with one operator was attained, thus permitting the entire lot of 5000 units to be placed in the hands of the retailer some five weeks after the inception of the project.

This number of all-steel tables of one size is generally considered a high production run and normally involves considerable financial investment in dies, jigs, fixtures, and other equipment with which to fabricate the units. Use of spot welding made possible the production of the 5000 tables at a minimum overall cost and so permitted large-scale local sampling of the market

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for this particular item in a space of time generally held to be insufficient to make even a cursory market analysis.

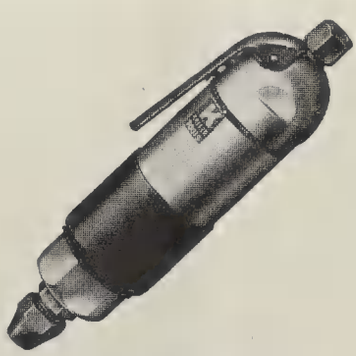
DIE GRINDER

Is Air Cooled for Continuous Operation

AN INCREASED-POWER pneumatic die grinder for continuous high speed operation has a one-piece housing of aluminum alloy with head, muffler, and throttle lever blending with the general housing contour.

Special construction features include the built-in oil reservoir which holds oil for eight hours' operation and which may be filled by simply removing one screw. Oil is metered to the grinder through an automatic feeder device incorporated in the tool.

Cool exhaust air circulates around the finned surface of the cylinder, permitting continued operation at high speed without over-heating.



Compact air-operated grinder

Bearings are rigidly mounted in end plates for perfect alinement and accuracy and packed with grease for 1000 hours' operation. A special shield keeps grease in and grit and dirt out.

THERMOPLASTIC TAPE

Provides Insulation and Protects Against Abrasion

TRANSPARENT and flexible, a new thermoplastic tape, which greatly facilitates inspection and servicing of equipment on which it is applied, is useful not only as electrical insulation but also to protect wiring, cables, and equipment against abrasion. The tape is heat sealing, flame resistant, flexible at low temperatures, and resists attack by acids, alkalies, moisture, oil, grease, and corrosive fumes. With proper adhesives, it may be bonded to fabrics, metal, ceramics, wood, and other materials.

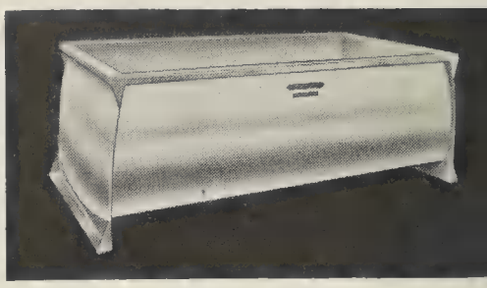
Fibron tapes, made by the Irvington Varnish and Insulating Company, have been applied successfully as gasketing material; in the construction of automotive and aircraft lighting and ignition harnesses; and in splicing plastics insulated wire and cable.

CURVED TANKS

Have High Strength For Many Uses

PRE-FORMING of the sides of stainless steel tanks to a curve determined by hydrodynamic principles has increased tremendously the tank's strength per weight, according to the Rodney Hunt Machine Company, which has been using such tanks in its textile wet finishing machines.

The success of this "built-in" natural curve opens up many possibilities for



Sides are curved for high strength

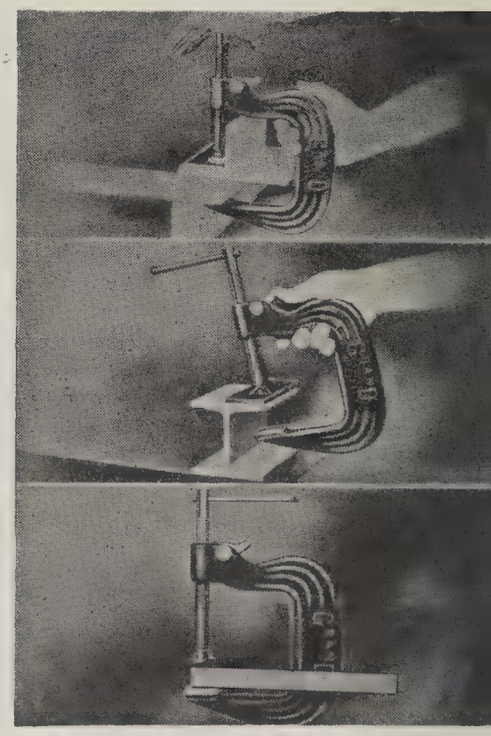
adaptations to other fields than textiles and the Rodney Hunt firm has already made tanks of this design for several applications in the chemical and food processing industries.

The tank illustrated shows how the curved sides do not have to be reinforced with supports which would be needed to resist pressures built up by liquids inside a typical straight-sided tank. This principle can be applied to a wide range of sizes and styles.

SPEED CLAMP

Tightened Quickly, Released Instantly

IN ADDITION to an extra deep throat for which there have been many requests, a new type of "C" clamp incorporates "quick-action" features. It is claimed that the clamp can be positioned instantly by simply pushing down on the ratchet screw (eliminating waste time and motion required to run down the conventional type of clamp screw) and tightening with a turn of the lose-proof handle. The clamp is said to release instantly by merely loosening the handle and pushing with thumb or finger on the trigger release pawl which frees the ratchet screw so



A push and a turn lock this new clamp; it is quickly released by the trigger

that the clamp is ready immediately for application to work of any other size or thickness.

This new Grand clamp is claimed to hold work with a firm tension grip on any surface, even slanting or irregular, and is equipped with replaceable ball and socket swivel to prevent shifting or creeping. The trigger release pawl is described as having hardened teeth which hold a meshed grip under spring tension on the ratchet screw while the clamp is set.

TOWING HANDLE

Telescopes Under Hydraulic Table

A TELESCOPIC towing handle has been added to the hydraulic elevating table made by the Lyon-Raymond Corporation. Extended, the handle provides means for easily moving the table from



For easy moving of tables

place to place. Collapsed, the handle is below and under the table top where it will not interfere with operations involving transfer of materials across the table or support of overhanging pieces.

EYE PROTECTION

Afforded by Gradient-Density Sun Glasses

SUN GLASSES that permit flyers to look directly at the sun by turning their eyes upward yet give them normal horizontal vision have recently been developed. Called gradient-density sun glasses, they shield the flier's eyes from the sky or bright sun above and the glare from water, sand, or other reflection below.

Through the center, they are comparable with ordinary sun glasses, transmitting about 20 percent of the light, sufficient for normal, daytime vision in sunlight. They are coated with a stainless steel film of microscopic thickness, the density of which is gradually increased toward the top and bottom of the sun glass lenses so that light transmission at these points is about 1/100th of one percent, sufficient for comfortable vision while looking directly at the sun.

The gradient-density sun glasses are made either with the gradation on both

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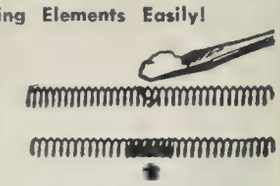
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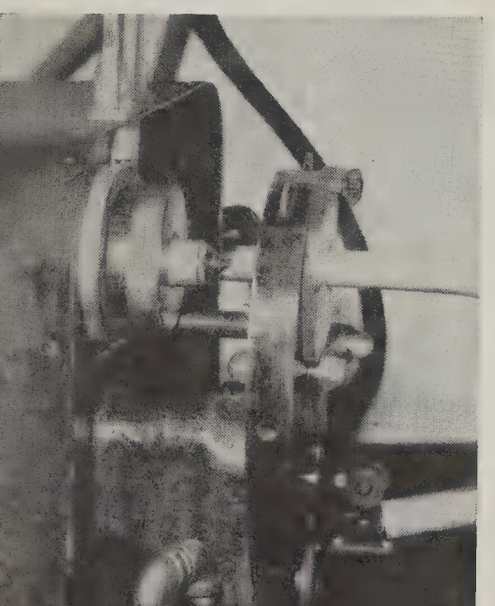
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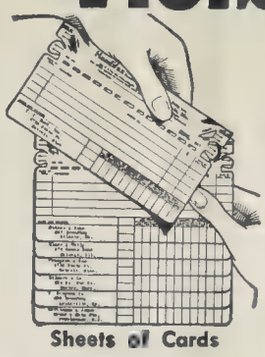
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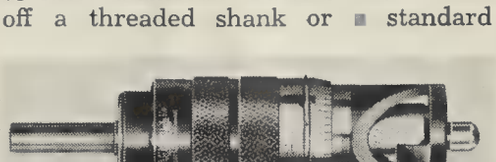
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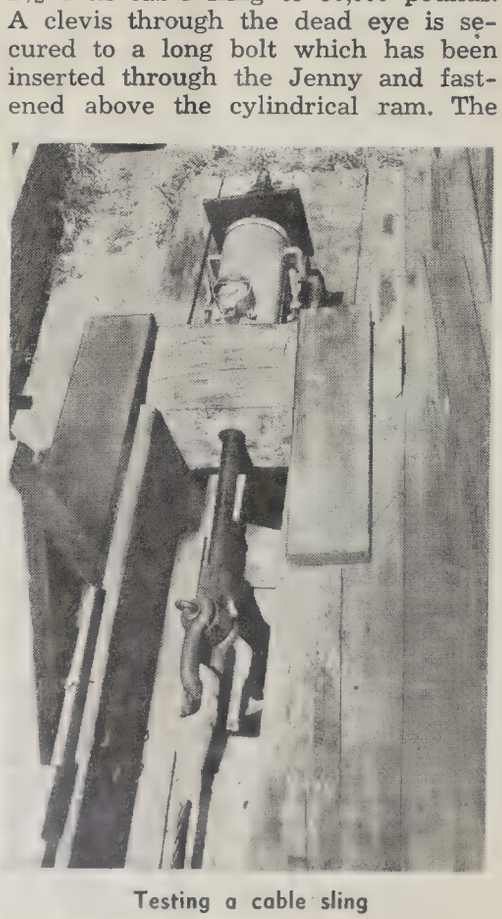
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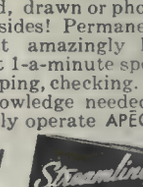
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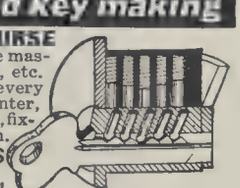


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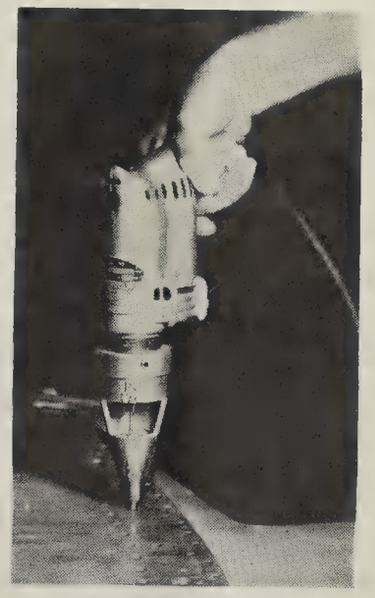
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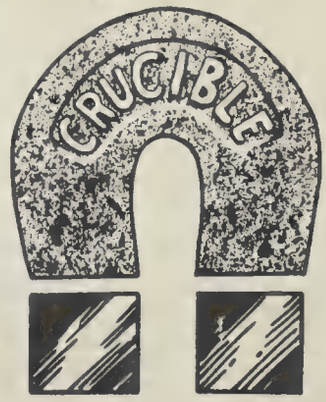
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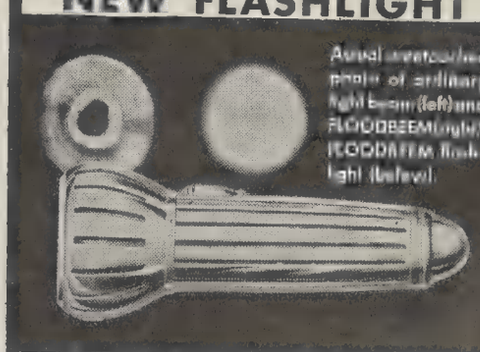


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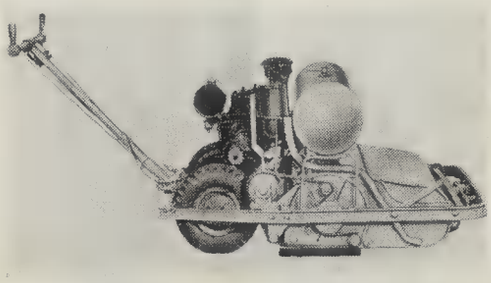
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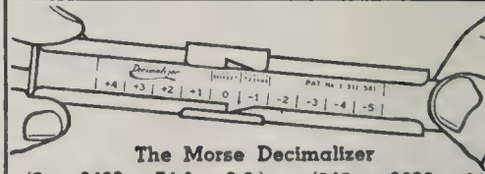
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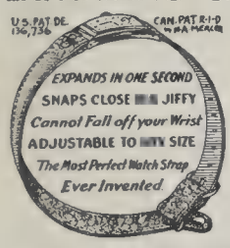
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(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

CATECHISM OF ELECTRICAL MACHINERY. This 48-page booklet presents in a simple way the most important features of common types of direct-current and alternating-current motors, generators, and control equipment. The text was prepared for those not familiar with electrical phenomena and terminology. Request Bulletin E100D. *Fairbanks, Morse and Company, 600 South Michigan Avenue, Chicago 5, Illinois.—Gratis.*

THE OBSERVER'S HANDBOOK FOR 1945 contains data on the planets and other astronomical phenomena, month by month; also lists of double and multiple stars, variables, four star maps, an ephemeris of the Sun, and miscellaneous astronomical data. Most amateur astronomers obtain this booklet each year. *Royal Astronomical Society of Canada, 198 College Street, Toronto, Ontario, Canada.—25 cents.*

A STUDY OF RADIANT BASEBOARD HEATING IN THE *I-B-R* RESEARCH HOME, by Alonzo P. Kratz and Warren S. Harris, presents the results of an investigation carried out to determine the effect of introducing heat into a room by means of long, low panels, heated by hot water, these panels being placed near the floor and extending along the exposed walls of the room. *Engineering Experiment Station, University of Illinois, Urbana, Illinois.—Gratis.*

DOW CORNING SILICONES, NEW ENGINEERING MATERIALS, is a 12-page illustrated pamphlet describing a family of synthetic materials of wide potential applications which are produced in many forms. These forms include fluids, greases, resins and varnishes, and silicone rubber. Silicones' outstanding property is the great extension of operating temperature ranges. *Dow Corning Corporation. P. O. Box 592, Midland, Michigan.—Gratis.*

PROPERTIES OF AMERIPOL D is an eight-page catalog section outlining the properties of an oil- and heat-resistant synthetic rubber. Illustrated with pictures of various Ameripol D products, this section serves as a guide to determine where the use of this synthetic is practical. *The B. F. Goodrich Company, Public Relations Department, Akron, Ohio.—Gratis.*

LIGHT FROM FLOORS is a 24-page illustrated booklet describing the peacetime possibilities of light-reflecting concrete floors. Results of a survey, involving over 300 lighting tests, are presented. Sections are devoted to recommendations for floor construc-

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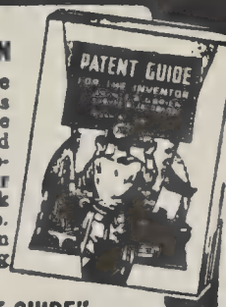
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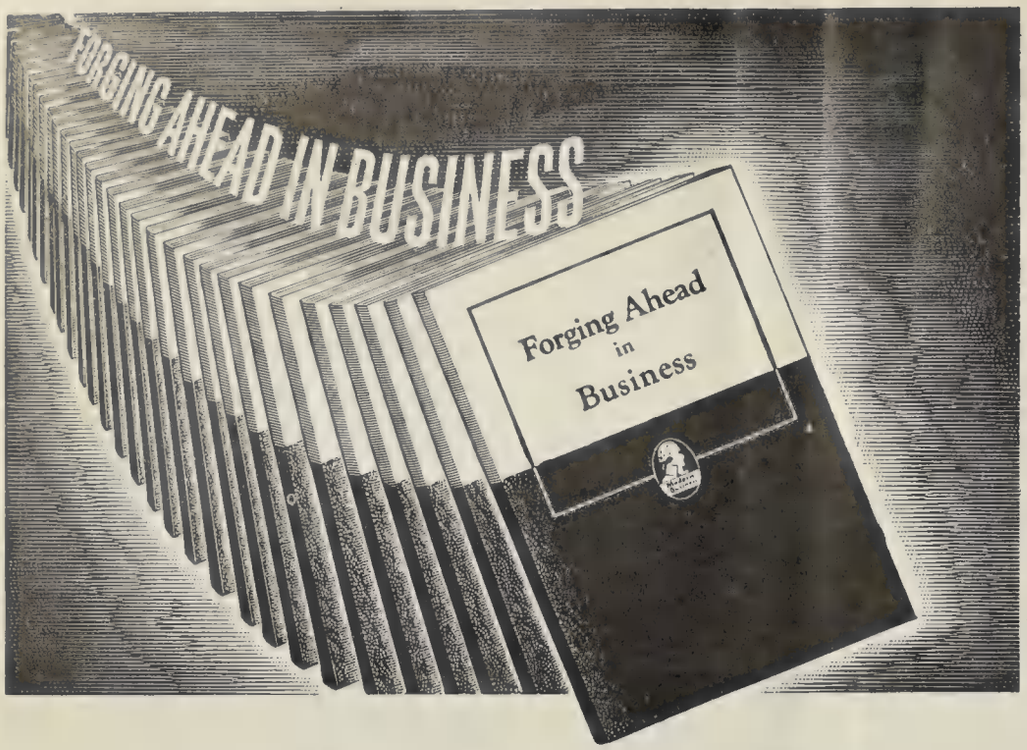
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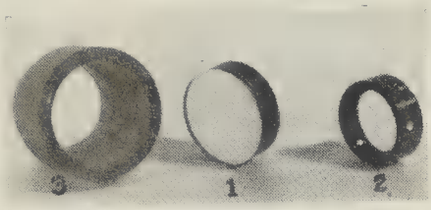
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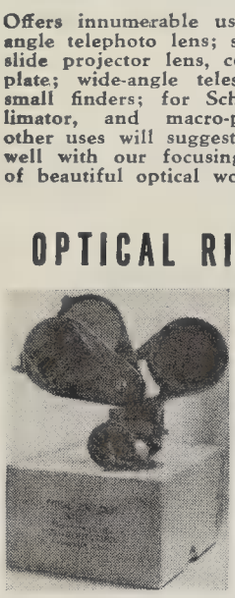
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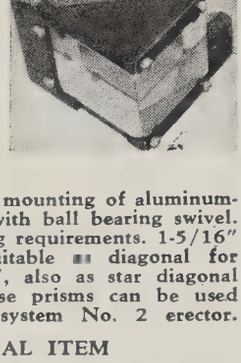


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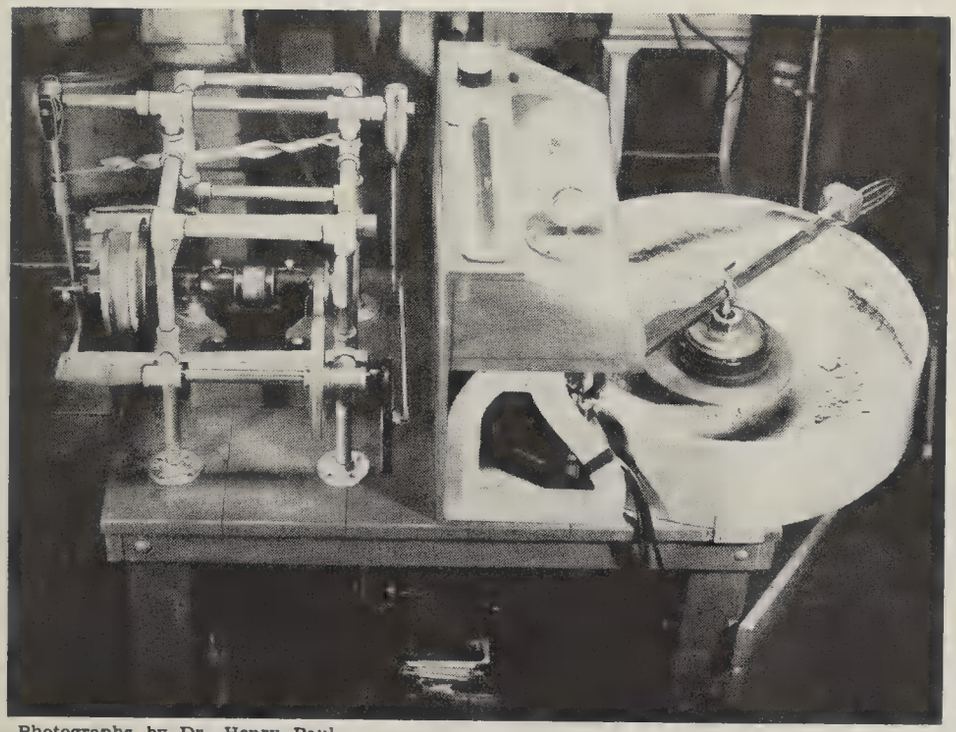
Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN THIS department in the October and November numbers Patrick A. Driscoll described the design and use of a telescope mirror grinding and polishing machine of the vertical-spindle, hand-lever type. Now in this and next month's numbers Dr. Henry Paul, 119 North Broad St., Norwich, N. Y., will describe his own machine (Figure 1) of the same general type, combined with a polishing machine. The grinding part is seen on the right in the photograph, the polishing part on the left, but the grinding part alone will be described this month. Paul's description is as follows:



Photographs by Dr. Henry Paul

Figure 1: Henry Paul's combined grinding and polishing machine

It is often the desire of the amateur to have one machine which alone is capable of handling the greatest possible variety of optical work. This combination grinding and polishing machine has very satisfactorily served for the past five years in making highly varied optics ranging from ordinary *f*/8 paraboloidal mirrors and optical flats to roof prisms and correcting plates for Schmidt cameras. The same motor is used to drive both grinder and polisher. A separating wall in the center of the machine serves to keep abrasives from straying over to the polishing side. The grinding spindle will handle disks up to 12″ diameter.

The sturdy table, 2′ wide, 3′ long, and 3′ high, was constructed of ⅞″ hard wood. Drawbolts were used to fasten the 3½″ square legs in place. Lag screws were also used at key points. Thus, joints may be tightened and the table kept solid.

A ½ h.p. capacitor type reversible motor is recommended if such a machine has plain bearings, although a 1/3 h.p. motor might be used. For less power than this, ball bearings should be placed at the greatest friction points. The motor was swung on a hinge at one side of its base, which facilitates the use of four interchangeable motor pulleys, 1″, 1½″, 2″, and 2½″ in size. While the weight of the motor may hang on the belt alone, a rubber-cushioned wedge supporting a part of the weight of the free side adds to smooth operation.

Starting from the motor, a V-belt drives a 10″ pulley (Figure 2) on the ¾″ jack shaft. The latter is supported in plain-bearing, self-alining hangers.

On the right-hand end of the same jack shaft, by means of a flange, is fastened a 10″ by ⅜″ steel disk, its face machined perfectly true and perpendicular to the shaft. Here, freedom from wobble affords beautifully smooth operation and is worth seeking. The disk might well be permanently welded to the shaft and then machined true.

The vertical grinding spindle proper was made from a saw mandrel having standard bronze bearings. Its top end has a standard 1″ 8-thread (specified right-hand). The shaft of these sturdy mandrels is usually about 1 3/16″ in diameter.

For the end-thrust bearing of the spindle a thick brass plate, or disk, was fastened over the bottom end of the lower bearing, and a ½″ hole was drilled or turned just deep enough into the lower end of the shaft so that it would drop over about three fourths of a ½″ ball bearing. After some operation such a ball will wear a small, efficient bearing point in the brass plate. Lubricate well with a large amount of thin cup grease or heavy oil. As a simple alternative the end of the shaft could itself, if turned to a dull-pointed cone, serve as a bearing.

The 10″ faced disk drives a 2″ by 10″ pneumatic tire fastened with rim cement to a heavy wooden disk turned to receive it. Two cast-iron flanges—one on either side of the disk is best—were bored to a *close* sliding fit on the vertical shaft. A small flat area was filed from top to bottom of this shaft and a ⅜″ setscrew from the upper flange against this keeps the rubber-tired, variable-drive wheel at the selected position on the vertical shaft. Without the flat area, setscrew marks will soon result in a wheel that is hard to slide up or down the shaft. A knee lever (flat board hinged on one side) permits the spindle to be stopped almost instantly by hard knee

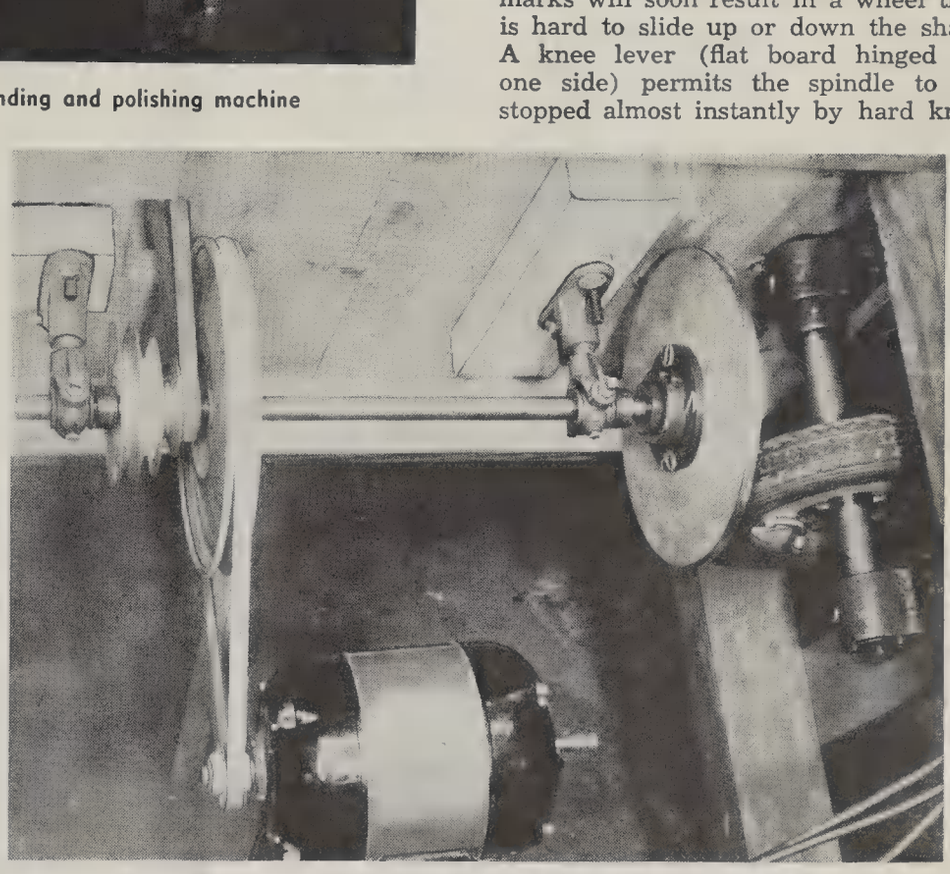


Figure 2: Same machine from below, with jack shaft and spindle

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pressure; a *really quick* stop may "save all." Until the switch is off, the tire skids on its driving disk. At the point where the shaft passes through the bottom of the 24" by 6" heavy-gage pan is soldered a sleeve 1" high and about ¼" larger in diameter than the shaft. Under the 1" 8-thread hex nut, which serves as a shoulder on the same shaft, or spindle, is placed a circular washer of soft aluminum turned down at the edges. This effectively keeps water and abrasive out of the bearing. Warning: Put a high-water mark on the pan. A drain plug also would be handy.

The hand lever, or pin bar, should be at least 9/16" or ⅝" in diameter. A ½" shaft hanger permits universal motion at the attached end. Three cables, the third permitting a reversing switch (very handy to run laps off their thread) run along this bar (a tubular pin bar with the cables inside would be neater and easier to clean) to the on, off, and reverse switch fastened within reach of the thumb at the hand grip. A bicycle handlebar grip is good here. The best clamp I have found for holding the central pin on the bar was made from a Castaloy laboratory clamp (the former No. 20195, now No. 5-766, Eimer and Amend, 633 Greenwich St., New York, N. Y.). Ordinary cast-iron clamps break easily (goodbye mirror), while a solid support cannot be easily removed for cleaning.

The head plates for attachment of the mirror lenses were made by brazing 1" 8-thread hex nuts to ¼" or ⅜" thick disks.

Speeds of this grinding head may be varied from 0 to about 400 r.p.m. The operation is smooth and quiet. Ordinary dry soap applied to the tire stops any tendency to squeak.

End of Henry Paul's description of his grinding spindle. Next month he will describe the successful and nearly unique polishing part of his combination machine, with the mirror rotating constantly in an edgewise position in a bath of rouge water, and working while you sleep.

ATTENTIVE readers will recall that in the November number Driscoll urged not exceeding a spindle speed of 200 r.p.m., warning, "Faster, disaster." They may therefore ask how Henry Paul gets away with double that speed (quadrupled centrifugal force). For one thing, his is an especially well balanced machine. For another, its user is especially well protected by a thick splash pan turned over a heavy ring. And the 400 r.p.m. is, anyway, only its outside speed, seldom attempted. Just exactly what happens by way of disaster? Unpredictable. Asked whether he had ever lost control of a mirror Paul replied, "Yes, one flew off and put a dent in the pan but luckily did not chip the mirror, or me." An 8" mirror at 400 r.p.m. represents a peripheral speed of about 10 miles an hour and might only knock the wind out of the recipient. Yet who, except the indestructible Popeye, would choose to be hit by such a slug? "Reasonably safe speeds," Paul comments in a letter, "go up to about 400 *edge* feet per minute, corresponding to 150 r.p.m. for a 10" mirror, 200 r.p.m. for an 8", 250 r.p.m. for a 6"."

Leo J. Scanlon of Pittsburgh, who also has used the hand-lever type of machine, reports that "while grinding does proceed at a rate proportional to the pressure applied, speed of rotation, and amount of overhang, and there is a strong temptation to speed up the machine, high speeds throw off the abrasive wastefully. Also, seizure, if it occurs, takes place so quickly as to end in disaster if the grinding surface becomes dry or warm. It is also," he continues, "a delicate venture to entrust the mirror, in the last stage of fine grinding, to a rotating tool, though I have done it frequently. Usually in this last stage and one or two preceding it I do not use the pivot pin but hold the mirror in my hands, with my foot on the motor switch. (Paul too states that he grinds the last ten minutes by hand with mirror at 5 r.p.m.—Ed.) I also try always to avoid passing the mirror over the center of the tool, since that favors seizing, especially if the mirror is not yet spherical. Incidentally, we always try to finish a mirror in fine grinding with a slightly raised center. It then is easy to get a sphere by polishing."

Scanlon mentioned, above, the effect of centrifugal force in throwing off the abrasive. Here Paul comments, "Increasing the viscosity of the water used will retard centrifuging off the abrasive before it is broken down, and therefore will decrease grinding time. To accomplish this, household gelatin may be used, or 'Metamucil-2,' a drug-store powder which may be stirred into the water until the desired viscosity is reached. But this thickening of the grinding water is recommended only for the hogging out part of producing deep curves such as *f*/0.6 to *f*/2, where working times of 50 to 100 hours have been reported. Here the worker will soon speed up his machine to hurry the job along. Thickening of grinding water offers no advantage at slow speeds and should not be done with fine abrasives at any speed. On shallow curves it is not worth the bother, as these work out in a very short time on the vertical spindle. In general, the hand-lever machine requires more skill to obtain much faster results than other types of machines."

Apropos, not of machines but of Paul, is a distinct contribution of his to the art of rough figuring by fine grinding of aspherical surfaces such as Schmidt corrector plates. "My luckiest find," he says, "is the use of the round, thin, microcope cover glass held down and moved about by the finger and used on the rotating disk just as the thumb is sometimes used in zonal figuring polishing. Such cover glasses are from ½" to ¾" in diameter and only 0.002" to 0.005" thick and are therefore flexible under the finger." This method might prove applicable when rough figuring mirrors of such depth of curve that the greater part of the parabolizing is preferably done in grinding.

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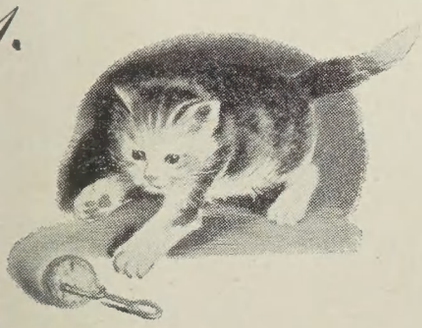
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Here's the *Inside Story* on Coming New

Radio-Phonographs

1.



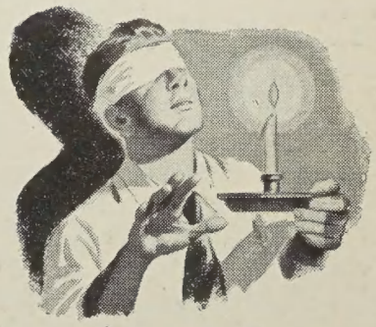
Goodbye scratch and rattle. A revolutionary Zenith Radionic development will bring out hidden beauty never heard in records before—miraculously free from surface noise and scratch. It will give records 10 times their former playing life, too! And only Zenith will have it!

2.



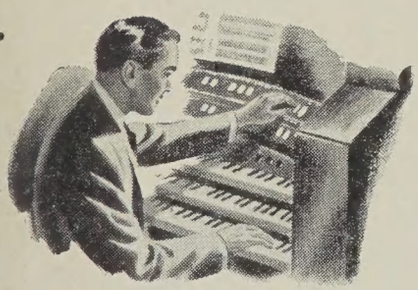
No painful pauses between records, so disturbing to listeners. New Zenith record-changers will be lightning fast, amazingly simple, utterly safe for records. Quiet, too—no annoying mechanical noises and clicks. You'll say there's a touch of genius in Zenith engineering.

3.



No more groping around in a dark well to load record-changers. Zenith will have no trays or drawers to slide out, yet Zenith player units will glide silently into full view, completely accessible—then glide back into the cabinet out of sight! It's another Zenith exclusive!

4.



Be your own music master with Zenith's new, improved Radiorgan. Over 64 tonal combinations at your fingertips. Like a master-musician you'll blend radio, or record or F-M music to your own taste . . . bring out gorgeous passages and shadings the way you want them.

5.



Plenty of storage space for records in coming new Zeniths. No more stacking favorite records and albums in dust-catching piles. They'll be safe, easy to reach in beautiful cabinets, with flat tops you never need to lift. Zenith designers have worked wonders.

Naturally Zenith Will Be a Step Ahead Because Zenith Concentrates on

RADIONICS EXCLUSIVELY

For 30 years, Zenith has been a world leader in radio "know-how" by concentrating on Radionics—*the science of radio waves.* This has made Zenith radios outstanding—so dependable that their owners have enjoyed unparalleled freedom from service expense. It has also made Zenith one of the "big 3" in radio sales.

Today, Zenith is still concentrating on Radionic marvels for war. Soon, you may enjoy many of them in the coming Zeniths—the finest radios we've ever built and the top values in the field. When you see and hear them, you'll know for sure that there's a touch of genius in everything Zenith does!

Buy More Victory Bonds!

For the Best in Radio Keep Your Eye on Zenith

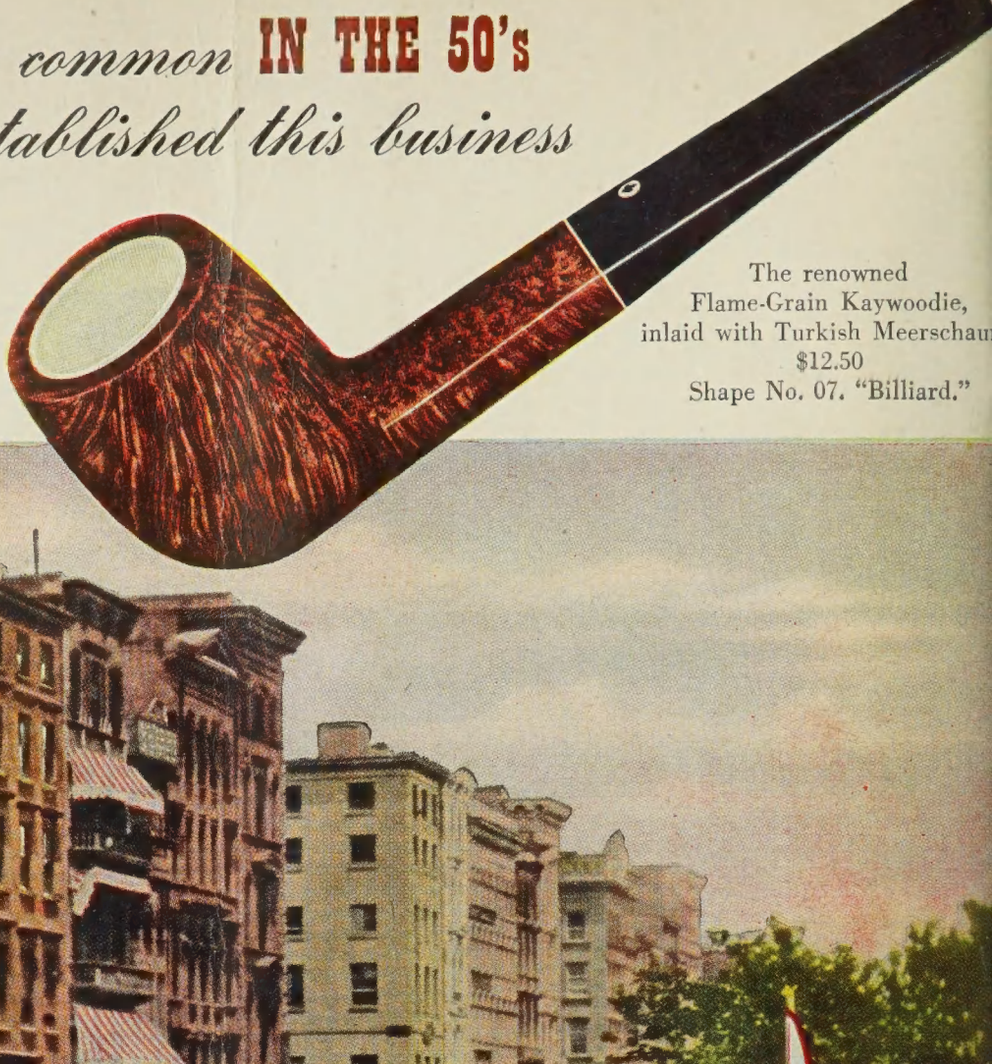
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Scenes like this were common IN THE 50's *when our founders established this business*



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Flame-Grain Kaywoodie,
inlaid with Turkish Meerschaum
$12.50
Shape No. 07. "Billiard."

PHOTO BY MATHEW BRADY



A rare old photograph, with authentic colors added, of Lower BROADWAY, NEW YORK CITY, as it looked to our founders when they were making pipes nearby. They began this business in 1851 at No. 59 The Bowery, and in 1860 moved to No. 121 William St. A reproduction of the Broadway illustration in colors, together with booklet illustrating Kaywoodie Pipes, will be sent on receipt of 10¢ to cover costs.

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suitable, but only
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